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16. ABSTRACT

The proceedings document the approximately 50 presentations made during the symposium, March 5-8, 1979, in San Francisco. Sponsored by the Combustion Research Branch of EPA's Industrial Environmental Research Laboratory-RTP, the symposium dealt with subjects relating both to developing improved combustion technology for the reduction of air pollutant emissions from stationary sources, and to improving equipment efficiency. The symposium was in seven parts, and the proceedings are in five volumes: I. Utility, Industrial, Commercial, and Residential Systems; II. Advanced Processes and Special Topics; III. Stationary Engine and Industrial Process Combustion Systems; IV. Fundamental Combustion Research and Environmental Assessment; and V. Addendum. The symposium provided contractor, industrial, and government representatives with the latest information on EPA inhouse and contract combustion research projects relating to pollution control, with emphasis on reducing NOx while controlling other emissions and improving efficiency.

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February 1979

Proceedings of the Third Stationary Source Combustion Symposium; Volume V. Addendum

Joshua S. Bowen, Symposium Chairman,
and
Robert E. Hall, Symposium Vice-chairman

Environmental Protection Agency
Office of Research and Development
Industrial Environmental Research Laboratory
Research Triangle Park, North Carolina 27711

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PREFACE

These proceedings document more than 50 presentations and discussions presented at the Third Symposium on Stationary Source Combustion held March 5-8, 1979 at the Sheraton Palace Hotel, San Francisco, California. Sponsored by the Combustion Research Branch of the EPA's Industrial Environmental Research Laboratory - Research Triangle Park, the symposium papers emphasized recent results in the area of combustion modification for NO_x control. In addition, selected papers were also solicited on alternative methods for NO_x control, on environmental assessment, and on the impact of NO_x control on other pollutants.

Dr. Joshua S. Bowen, Chief, Combustion Research Branch, was Symposium Chairman; Robert E. Hall, Combustion Research Branch, was Symposium Vice-Chairman and Project Officer. The welcoming address was delivered by Clyde B. Eller, Director, Enforcement Division, U.S. EPA, Region IX and the opening Address was delivered by Dr. Norbert A. Jaworski, Deputy Director of IERL-RTP.

The symposium consisted of seven sessions:

Session I:	Small Industrial, Commercial and Residential Systems Robert E. Hall, Session Chairman
Session II:	Utilities and Large Industrial Boilers David G. Lachapelle, Session Chairman
Session III:	Advanced Processes G. Blair Martin, Session Chairman
Session IV:	Special Topics Joshua S. Bowen, Session Chairman
Session V:	Stationary Engines and Industrial Process Combustion Systems John H. Wasser, Session Chairman
Session VI:	Fundamental Combustion W. Steven Lanier, Session Chairman
Session VII:	Environmental Assessment Wade H. Ponder, Session Chairman

VOLUME V

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by

J. S. Bowen, Chief
Combustion Research Branch
Industrial Environmental Research Laboratory-RTP

THIRD SYMPOSIUM ON STATIONARY SOURCE COMBUSTION

Introductory Remarks

by

J. S. Bowen, Chief
Combustion Research Branch
Industrial Environmental Research Laboratory-RTP

Good morning! It is most encouraging to see so many of you here this morning. This Third Symposium on Stationary Source Combustion is one of the numerous technology transfer activities sponsored by the U.S. Environmental Protection Agency. Such meetings provide a medium for exchange of the latest information concerning our technology development and assessment programs aimed at improved pollutant emission control techniques. They offer the opportunity for the researchers and investigators, the manufacturers and the users of the processes and equipment, the policy makers, the strategists, and the regulators to share their thoughts and their results. They allow those who are interested to be brought up to date on the current status of the development and the evaluation of those pollution control techniques presently available and those holding promise for future application. So your presence really reflects the strong interest on the part of the many sectors represented in solving the Nation's environmental problems.

It has been a year and a half since our second symposium in New Orleans in September 1977. Now as then, the primary emphasis of the meeting is on combustion process changes or modifications for controlling nitrogen oxides and other combustion-generated pollutants from a broad range of stationary combustion sources. In that year and a half many things have happened which impact on our Combustion Modification and Nitrogen Oxides Control Program and much important and encouraging R&D work has been accomplished. We have experienced the aftermath of the earlier "energy crisis." Prompted by a restricted supply of natural gas and the uncertainty of foreign supplies of oil, the Nation's energy plan calls for the drastically increased reliance on coal in the long term as a fuel for many combustion systems which formerly used oil and gas. There is the added emphasis on conservation in all energy-related areas to permit available fuel to go further in meeting our energy requirements. As an example, wood is becoming increasingly popular as a fuel, both by homeowners and by a number of industrial companies. With respect to regulatory standards for nitrogen oxides, we note the trend toward relaxation, at least in the near term, of the standards for automotive emissions, and the trend toward implementation of more rigorous standards for stationary sources. Currently, the development of a short-term ambient standard for nitrogen oxides is in progress. Many of these regulatory trends may necessitate more effective controls as well as controls for a wider variety of stationary sources.

In the Environmental Protection Agency's Office of Research and Development there has been an increased emphasis on the consideration of problem areas from a broader perspective, with the need for a greater awareness of the total impact of the applications of control technologies. Thus, we have seen extensions of our programs to include and place strong emphasis on environmental assessment and integrated assessment efforts. These study the multimedia impacts of processes or of control technologies giving comprehensive consideration to hundreds of potentially hazardous pollutants rather than to the mere half-dozen or so criteria pollutants considered in the not-too-distant past. And, also, there has been greater involvement with other government agencies, particularly DOE, since we are working in strongly energy related areas. All of these factors have had an effect on our program as will become more apparent from some of the discussions in this meeting. Lastly, the R&D results themselves have indicated the prospect for significant improvements in NO_x controls through such approaches as the utilization of improved burner designs, the optimization of combustion modification techniques, and the application of advanced processes. These, however, are the subjects to be covered in the various papers to be presented and I am sure we will find them very interesting.

I would like to take this opportunity to introduce several people who have a key role in the planning and presentation of this symposium. Most of them are members of the staff of the Combustion Research Branch of EPA's Industrial Environmental Research Laboratory in Research Triangle Park, North Carolina. First, I would like to introduce Bob Hall, who is the Vice-Chairman for the Symposium and has had the major responsibility for the planning and arrangements. He is also the Session Chairman for the First Session on Small Industrial, Commercial, and Residential Systems. Next, I will introduce Dave Lachapelle, who is the Session Chairman for the Second Session, which addresses Utility and Large Industrial Boilers. The Chairman for the Third Session is Blair Martin. The subject of his Session is Advanced Processes. Another

Session Chairman is Jack Wasser. His Session will cover Stationary Engines and Industrial Process Combustion Systems. And also, I would like to introduce Steve Lanier. He is the Session Chairman for the Session on Fundamental Combustion Research. The Chairman of the Final Session, on Environmental Assessment, is Wade Ponder. Wade is a member of IERL-RTP's Process Technology Branch. He is at another Symposium at this time but will be arriving later in the week and you will meet him then.

Now, let us proceed with the Symposium Agenda.

WELCOMING ADDRESS

by

Clyde B. Eller, Director
Enforcement Division, U.S. EPA Region IX

A copy of Mr. Eller's welcoming address was not received in time for the publication of this volume.

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OPENING ADDRESS

by

N. A. Jaworski, Deputy Director
Office of Research and Development
Industrial Environmental Research Laboratory-RTP

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THIRD SYMPOSIUM ON STATIONARY SOURCE COMBUSTION

OPENING ADDRESS

BY

N. A. JAWORSKI

On behalf of John K. Burchard, the Director of EPA's Industrial Environmental Research Laboratory in Research Triangle Park, N. C., and Steven R. Reznek, the Deputy Assistant Administrator for EPA's Office of Energy, Minerals and Industry, in Washington, D. C., I welcome you to the Third Symposium on Stationary Source Combustion.

Let me begin my opening address by giving you a mini-course on the EPA's organization. As many of you know, Douglas Costle is our Administrator, and Barbara Blum is our Deputy Administrator. Reporting to them are six Assistant Administrators for the following areas:

--Enforcement.

--Air and Waste Management.

--Water and Hazardous Materials.

--Planning and Management.

--Toxic Substances.

--Research and Development.

In addition there are ten Regional Administrators located throughout the USA.

Our Assistant Administrator for Research and Development is Stephen J. Gage, who oversees the programs of five principal offices dealing with:

--Health Effects.

--Transport, Fate, and Ecological Effects.

--Monitoring and Quality Assurance

--Criteria and Assessment.

--Environmental Control Technology.

Most of the field effort under the last heading, Environmental Control Technology, is being done through two Industrial Environmental Research Laboratories. One of those Laboratories -- which is sponsoring this symposium --is located at Research Triangle Park, N. C. The other, under the directorship of David Stephan, is located in Cincinnati, Ohio.

Within the Industrial Environmental Research Laboratory in N. C. there are three major Divisions. The Utilities and Industrial Power Division, headed up by E. L. Plyler, is responsible for Flue Gas Treatment including SO_x, NO_x, and Particulate Control. The Industrial Processes Division, headed up by A. B. Craig, is responsible for environmental assessment and developing control technology for the Chemical and Metallurgical Industries. Process measurement techniques used by the entire Laboratory are developed and recommended by a branch within the Industrial Processes Division. The third Division within IERL/RTP is the Energy Assessment and Control Division. R. P. Hangebrauck is the Division Director. This Division is responsible for fuel processing (such as Coal Cleaning, Coal Gasification, and Liquefaction), and evaluating advanced processes such as Fluidized Bed Combustion, and for Combustion Research. This activity, Combustion Research, is the subject of this meeting. In addition, topical issues not within the domain of the three divisions are developed by the Special Studies Staff under the direction of Gene Tucker.

Beginning in the late 1960's and extending into the early 1970's, major thrusts of our Laboratory were in Flue Gas Desulfurization and in Particulate Control. However, combustion research is now the single largest environmental control technology program within EPA. The focus on this technology is primarily due to two reasons: (1) the projected NO_2 ambient level is expected to increase significantly over the next 10 years; and (2) the possibility of a short term NO_x standard within the next year. These two factors significantly increased EPA's concerted research effort primarily in the area of combustion modification.

Within EPA we are very enthusiastic about our combustion modification program as an environmental control for NO_x and other pollutants for four main reasons:

1. Combustion modification is relatively low in capital costs as compared to other control systems.
2. It is relatively low in operating and maintenance costs.
3. The low projected energy penalties and the fact that in some cases there is an energy saving.
4. The relatively low impact on other media resulting from combustion modification as contrasted to, for example, FGD, or where we create a solid waste disposal problem.

In addition, the projected effectiveness of NO_x control appears to be very promising.

Within the next 4 days you will be given a chance to hear some of the successes of our research and development effort. Many of the participants in this endeavor, both private and at government institutions, have done an excellent job in this area. Some of these I would like to recognize are: Acurex, Battelle, Energy and Environmental Research Corporation, Exxon Research, IGT, KVB, Massachusetts Institute of Technology, and Rockwell International.

Efforts also have been enhanced by the manufacturers of combustion equipment. Some of these that have been very instrumental are Babcock and Wilcox, Combustion Engineering, Foster Wheeler, and Pratt and Whitney.

I would also like to recognize the contributions of the electric utilities both private and public and of the industrial segment who are also enhancing the results gained from our and other efforts in combustion modification. As many of you are well aware, the final proof of this technology is in the field testing. Some examples of the fine cooperative effort include:

--Exxon Research and Engineering's efforts over the past 8 years in testing more than 40 utility boilers, the majority of which were coal-fired. This required very close cooperation with such utilities as the Alabama Power Co., Arizona Public Service, Georgia Power, Potomac Electric Co., Public Service of Colorado, Salt River Project, Southern Electric Generating Co., Tennessee Valley Authority, just to name a few.

--Gulf Power's cooperation on a 2-year field study to determine the effect of combustion modification on tubewall corrosion.

--Field tests performed by Acurex, Combustion Engineering, and other contractors have involved utilities throughout the U. S.

--The close working relationship between EPRI and EPA is another example of how industry and government can work together.

We look forward to continued close cooperation with these and other organizations in the future. Such efforts will be beneficial to all of us. For example, plans are being made now to field test a new low NO_x coal burner design which was funded by EPA.

It is time for the technical session to begin, so have a good and productive symposium. I encourage you all to meet with our IERL/RTP Staff, talk to the researchers, and have a good stay here in San Francisco.

Thank you.

COMBUSTION MODIFICATION CONCEPTS
FOR STOKER-BOILER APPLICATION

by

John H. Wasser, IERL-RTP

ABSTRACT

A contract effort, now in negotiation, is described. The program will apply combustion modification concepts investigated in prior government and industry programs to full-scale coal fired stoker boilers. In Phase I, the contractor will select and negotiate for the utilization of two representative large industrial spreader stoker systems. A comprehensive Operation Plan will be prepared to bring together all elements of the program in a study that will address the problems involved in applying new technology to stoker systems and including design of the hardware for applying the combustion modification concepts to the specific units. While the plan is under study for EPA approval, the contractor will conduct the baseline study of the boiler systems. After approval of the Operations Plan, the contractor will construct the modifications to the system and proceed with the comprehensive study of the modified system.

The program will continue with analysis of the data and preparation of a thorough evaluation of the environmental aspects of the applied modification concepts. Subsequent to the analysis and evaluation, a document will be prepared in cooperation with boiler owners and manufacturers that will facilitate application of the results of this program to new design and retrofit installations.

In Phase II, the contractor will apply combustion modifications to other types of stoker systems. Boiler systems representative of commercial moving grate and underfeed stokers (about three units) will be selected for the program. This program phase will consist of the same series of tasks as the large spreader stoker phase.

An industrial review panel will be formed to provide practical guidance for the program and ensure that the results will have the maximum benefit for the stoker boiler industry.

BACKGROUND

This paper will describe a new contract effort now in negotiation. The contract will relate to one of several studies of a stoker coal fired boiler research, development, and application assessment program. The other two related contracts in the program are:

> EPA 68-02-2627, Battelle-Columbus Laboratories, "Evaluation of Emissions and Control Technology for Industrial Stoker Boilers."
>
> DOE/EPA EF-77-C-01-2609, ABMA/KVB, "A Testing Program to Update Equipment Specifications and Design Criteria for Stoker Fired Boilers."

The current status of these two contracts was described by the first two speakers in this morning's session. Experimental efforts for these two contracts should be completed in the second half of calendar year 1979.

The contracts now in progress are essentially establishing the state-of-the-art for stoker fired boilers: one by applying combustion modification to smaller scale units and scaling up to a mid-size unit; the other by evaluating operating modifications on full scale units. This information will be the major background material for the new contract effort to build on.

Prior field testing of industrial boilers by KVB in two contract programs, already completed, also included studies of stoker boilers and served to establish stoker emission performance characteristics. An earlier research study by Battelle on a small scale stoker provided valuable information on emissions and included a survey of stoker equipment current designs and processed fuels for stoker application.

Comprehensive sampling and analysis methodology, currently in use and continuing development, will be a major factor in this new effort. It will enable an indepth evaluation of the applied technology and will thus define the environmental impact/acceptability of new applied emissions control technology for stoker boilers.

PROGRAM SCOPE

The combustion modification stoker program has been divided into two phases to differentiate between spreader and non-spreader stokers. Phase I will study spreader stokers exclusively. Since they are regarded as the most significant type of stoker from the standpoint of increased coal utilization in the U.S., they will be considered first. This is also being done to coincide with the funding availability: current funding is assured; future funding is less definite. The Phase I work will involve sequential modification and testing of two relatively large [100,000 to 300,000 lb steam/hr (45,000 to 136,000 kg steam/hr)] spreader stokers, each requiring approximately 1 year's effort.

Phase II will study moving grate and underfeed stokers. Three of these units will be involved in the program over a 27-month period. These units are expected to be substantially smaller than the spreader stoker boilers used in Phase I. Again, the boilers will be studied sequentially to complete work on a unit by unit basis to minimize adverse effects if funding is restricted. The total program is expected to require approximately 51 months with a total expenditure of nearly $4 million.

PROGRAM OPERATION CYCLE

The program operation cycle will be followed once for each of the five stoker boiler units to be studied. Each cycle will consist of the same six tasks.

Task 1. Systems and Fuels Selection

The contractor will use reported field test results and R&D information on combustion modifications integrated with a perspective of the stoker boiler population spectrum in the U.S., to select and negotiate for utilization of a representative industrial stoker system fitting the phase subject. The unit selected will be in the representative size range for the type stoker involved and the existing emissions control equipment (cyclone, ESP, filter, etc.) will be considered in the selection process. Negotiation will be critical as the boiler owner/operator will have to be cooperative in permitting modifications, arranging operation schedules, and purchasing fuels. Negotiations will explore all possibilities for cost sharing.

The contractor will then select additional fuels for use in the program operation based on availability and compatability with the stoker system selected. Fuels selection, especially cleaned, blended, or processed coals, will be limited to those available in sufficient quantity in the timeframe of the evaluation program. Coals selected will be representative of major classes or regions.

Task 2. Operations Plan and Modifications Design

The contractor will develop an operations plan to experimentally investigate the environmental aspects of combustion modifications applied to the stoker system involved with each cycle. This operation plan will also include the design of the hardware modifications that will be required to implement the application of the combustion modification technology.

Potential combustion modifications for study include reduced excess air, staged combustion (overfire air jets), improved aerodynamic overbed mixing, flyash reinjection, zoned primary air control, and any other promising techniques or combinations of techniques the contractor considers feasible for incorporation in the specific boiler system. Consideration of these modifications will be organized into an optimum system design for determining the best method for minimizing emissions from the specific stoker system under study.

The plan will include requirements for a Level 1 EA (including Bioassay) for each major coal/modification technique combination after an optimum configuration is established in the test program based on criteria pollutant measurements. Level 2 EA is planned for major problem areas that are identified in the Level 1 analysis. The plan and design will be submitted to the EPA Project Officer for review and approval before the work is undertaken.

The plan will include requirements for determination of corrosion rates by the ultrasonic probe method to establish if increased rates will occur in relation to the combustion modifications technology.

Task 3. Baseline Systems Study

As the Operations Plan and Modifications Design are being reviewed by EPA, the contractor will conduct the baseline experimental program on the unmodified system. This part of the program will involve establishment of procedures and techniques for conducting the required experimental work and cooperative operating procedures with the boiler owner/operator personnel, as well as establishment of the baseline emissions for future comparisons. The baseline study will include environmental assessment data collection.

Task 4. Modification Construction and Test Program

After completion of the baseline study and EPA approval of the operations plan/system design, the contractor will construct and incorporate the modification design into the stoker system. This work will be accomplished in full cooperation with the boiler owner/operator and any construction subcontractors. After construction completion, all parts of the modified system will be checked for proper functioning. The contractor will conduct the experimental program as described in the Operations Plan, systematically studying the comprehensive emissions characteristics of the modified boiler system for each of the fuel/ modification combinations over a range of typical stoker boiler operating conditions. The study will include determination of Level 1 Environmental Assessment pollutant groups and specific Level 2 Environmental Assessment pollutants that are responsive to the combustion modification control technology as well as the criteria pollutants.

Task 5. Data Analysis and Assessment

Based on the results of the experimental program, the contractor will analyze the data and make an indepth assessment of the pollution control potential of the modified stoker boiler system. This evaluation will relate the control potential to the overall environmental acceptability of industrial stoker coal fired boilers. The impact of this control technology on the national environmental/energy outlook will be assessed. Recommendations concerning the future application of combustion modification control for stoker systems will be made.

Task 6. Application Guideline Document

Assuming that the results of study Phases I and II establish a significant improvement in the environmental status of industrial spreader stokers, the contractor will prepare a guideline document that will permit industrial application of the successful combustion modification concepts. A document will be prepared at the end of Phase I for spreader stokers; another, at the end of Phase II, for the other types of stokers.

INDUSTRIAL ADVISORY COMMITTEE

An industrial advisory committee will be arranged by the contractor to review plans and progress at each step. This committee will provide practical guidance for the program and ensure that the results have the maximum benefit in the shortest possible time for the stoker boiler industry. The committee will be vital in the development of the Application Guideline Document.

LUNCHEON ADDRESS

by

Peter Schwartz
Manager, Future Studies
S.R.I. International

This luncheon address, was recorded and transcribed for inclusion in this volume.

Robert Hall: Futurists analyze trends and forecast what may happen ten, twenty, thirty or more years from now. These are no blue sky acrobatics. They specialize in long range possibilities, base projections on sophistocated work with economic and social trend lines, mathematical models, the known and the unknown. The ability to organize unrelated information is crucial in this field. Edward Cornish, president of the 50,000 member World Future Society foresees a growing demand for such forecasting. Why? Because of the lightening fast change as we approach the twenty-first century, and new lifestyles, markets, technology, politics and many other developments.

Future study is a serious concern of business and government executives. These people must deal with these developments or fall behind. We at this meeting are concerned with the environment and with energy. We are very fortunate today to have with us Peter Schwartz who is the Program Manager for Future Studies at S.R.I. International. This was formerly the Stanford Research Institute. He's led studies on future problems and long term interactions of energy, environment, economic and social forces. He is now completing a major long term study for California energy future. Peter is also Vice President of the Portola Institute, which is the producer of the Whole Earth Catalogue. I'm sure you're familiar with that, and with the Energy Primer. And today Peter will talk to us about Changing Values and the Environment. Peter.

PETER SCHWARTZ: Thank you. It's a pleasure to be here. I always enjoy coming up to the Sheraton Palace for lunch. If some of you have heard my talk before, or some parts of it, and I hope I won't bore you. And the rest of you who have probably eaten too much, if you want to nod off a little bit this is probably the least essential part of your program, so I won't be offended.

What I want to talk a bit about are some of the long term forces that are going to shape our attitudes toward environmental policy, and how those might be changing in the years ahead. I want to focus especially on the question of values, because most of the time forecasters are wrong. Consistently wrong. And we've tried to figure out why people are wrong when they look at the future. And it seems to me that the two reasons we are most often wrong about the future are: one, we fail to anticipate innovation, that is the new things on the horizon that are likely to affect us; and secondly, we fail to adequately consider values, especially our own. That is, we want the future to turn out a certain way. We have a stake in it ourselves. And so our attitude toward forecasting generally is that we want the future -- we want the particular forecast to fit our own hopes and aspirations. And hence, we deliberately, quite unconsciously, blind ourselves to the realities we see. So what I want to do is to focus on those questions of value, in particular as to how those might be changing and what effect they might have in the long run on environmental policy.

I think it's important however to digress for a moment and give you a sense of the state of the art of the forecasting profession. We're not really very good at it. We're a bit like economists. That is we study the past and we study the present and we generate some models, and out of that we try and look ahead. And an incident not long ago will illustrate the level of competence of the profession. My wife and I are backpackers, and we were hiking in the Sierras last summer, and we were trudging up the trail, coming up to a pass, and up in the pass we could hear some men in the midst of a debate. They were arguing. And as we got closer the shape of their debate began to come clear to us. Finally we discerned that the participants were a doctor, an architect and an economist. And they were in the midst of a debate on who's profession was the oldest. And they were going around and around for a long time, and as we got closer we could hear the debate coming to an end, to denouement. And finally the doctor said, "Now look, I've got absolute proof as to who's is the oldest profession. One need only look to the Bible and you'll see there in the first few pages of Genesis that God anesthetizes Adam -- puts him to sleep -- operates, removes a rib, and creates Eve -- clearly the first act of surgery. Hence medicine is the oldest profession".

Well, the architect says, "Now look, you want to use that kind of proof, one need only go a few paragraphs earlier in Genesis and you'll see that God created the heavens and the earth out of the chaos -- really the first act of architecture. Hence architecture is the oldest profession". And the economist just smiled at them both and said, "So who do you think created the chaos?"

So, I suggest you take what I say with a very large grain of salt, and remember that most of the time we're wrong. Okay. Get down to it.

I'd like to draw an analogy to begin with, and that is when one thinks about the world there are different levels at which one can think about it. And the analogy I want to draw is to medical diagnosis. That is, there are many different ways in which we can diagnose a patient if we were a doctor. First of all we could focus on symptoms -- the obvious things, temperature, runny nose, broken arm and so on -- symptoms of disease. And we can treat those symptoms -- you know, we can give 'em a decongestant for the nose and we can give 'em things to reduce temperature and so on. However we could step up a level higher and interpret those symptoms as a disease syndrome. That is, looking for the causative agents, like bacteria for example. And then we might prescribe antibiotics. But arguing about diagnosis of symptoms doesn't tell you much about disease. So that the next level is the disease level.

We can go one higher level still. We can wonder why is this person sick. How is it that he has come to be ill? And one might then look at, for example, a breakdown of the immunity system in the organism -- in the person. And one might look at how is that to be treated. What is it that you can do to particularly bolster that immunity system so as to prevent future recurrences of the disease.

Finally one wonders then at the highest level, how is it that that immunity system itself broke down. And that's the level of the sort of psychosomatic causes -- basic questions of lifestyle and way of life. What is it that the person is doing, on the whole, that makes them susceptible to have their immunity system broken down, to become ill, to generate those symptoms.

Now I suggest that part of the problem in the environmental debate, and part of the problem consistently in thinking about the future, is we are talking about different levels of diagnosis. That is we are dealing with different points, we're dealing with symptoms on the one hand versus the equivalent of disease syndromes versus the equivalent of immunity systems breakdown, and finally basic questions of how we choose to live. It's that last level that I'm going to talk about most of all -- that question of how we choose to live and it's implications. Because I think that's the level on which ultimately the long term direction of our society will be decided. That is, how each individual in our society chooses to live.

To do that I want to go backwards in time a bit -- want to go back in history. This French historian named Ferdnand Braudel (phonetic spelling: Brawdell) wrote a remarkable book called The Mediterranean and the Mediterranean in the Era of Phillip II. And what's interesting about Braudel's book is the kind of history he writes. Most of us when we studied history in school studied it in the form of so-and-so killed so-and-so and this person was elevated to the throne and this new land was discovered and a new invention was made and so on as if that were history, as if that explained our past. Well, Braudel writes such a history, he writes that first level of history, the level of events. But that doesn't really tell you much about what's going on. That only tells you about what happened. To understand more about what's going on one needs to write a second history which places those events in the context of social and political forces that are of a more enduring sort. And so he writes a second history of that period. But that in itself doesn't really tell you the long term evolution of that situation. It will allow you to explain how it came to be that way and what its long range implications are. He says one must go a level deeper -- that is, the more enduring forces of geography, of resources, of values, culture, of basic belief systems themselves. Because when one looks at those then one begins to see the causative agents behind those higher levels of history. And so he writes a third history of that region at that time. And that's much longer in scope.

Well, that's what I want to do, is again focus at that bottom level historically -- just as we want to focus on the question of basic ways of life.

When we do that we see that, at least in our civilization, we have been on a trend that's at least eight hundred to a thousand years old. Various writers have called it different things. Robert Heilbroner called it the Great Ascent. Many different writers have given it different names. We prefer to call it the Modernization Trend. And it is the trend that Western civilization has been on for at least the last millennium, and it has gradually swept over almost the entire world. And we wonder whether it's going to continue.

Now, I want to say a bit about the nature of that trend and what we really mean by the Modernization Trend. It has four aspects in particular. Number one -- the secularization of values. By that I mean the source of our personal values has shifted over time. At one time our values came from two places, either from tradition and culture -- that is, my father did it this way, the village always did it this way, the chief told us to do it this way -- or on the other hand, from imminent religious experiences -- that is, I experienced God, or the Priests told me that they experienced God and here's how it's going to be. Gradually we shifted the basis of our values from such transcendent, imminent and traditional sources to secular sources. We sat down and we figured it out. That's an important shift, because now the source of values is not some fixed, divine order permanently and forever etched into the nature of things, but is created by man himself. It is by the choices and by our intellect that we choose to live.

Okay. That was one shift. The second is the source of our knowledge. Originally knowledge came from one primary place, experience -- what happened to me in my life and the experiences of others. Gradually knowledge came to be scientific knowledge. I suspect most of us in this room are scientists in one way or another -- I'm an engineer by education -- and the power of scientific knowledge has swept over the world. And scientific knowledge has some important characteristics; and that is that personal experience matters relatively little to scientific knowledge, and empirical evidence and the shared procedures of a scientific method and the approval of a larger community matter far more. So that the basis of knowledge moves away from the individual and much more toward the methods of a particular culture.

The third element of the long term modernization trend is economic rationalization. The most important of those secular values was economic efficiency -- that is, those values which would lead to higher levels of production and higher levels of wealth for all. And increasingly more and more of our social activities are governed by economic rationality.

The final element of that modernization trend was industrialization -- the particular application of scientific and technological knowledge and secular values in an economic sphere. And that is, more and more of our activities came to be industrialized -- that is, breaking them down into smaller components so as to make them effective and efficient. So that now not merely do we produce goods by means of industrial activity, we are increasingly making services industrialized as well, so that we have a health care industry and an education industry. And when you have an education industry then you can begin to apply economic criteria to education; and so you can come up with the notion, for example, of over-education as if a person could have learned too much.

Those are the four elements of the Modernization Trend -- secularization of values, the scientification of knowledge, the dominance of economic rationality and industrialization of human activity. More and more of our lives are governed by the Modernization Trend. We wonder if that's going to continue. I think the events in recent weeks in Iran are indicative of the uncertainty with respect to the long term direction of that trend. Let me suggest a number of other aspects that indicate that that trend may be in for some problems. Historical studies of times of revolutionary change have all suggested one important characteristic of those periods of revolutionary change -- that there are some common indicators that tend to rise rapidly about that time and then seem to fall thereafter. Such indicators are rise in violent crime, alcoholism, hedonism, alienation and various forms of breakdown of the family. Now all of those are things that I think we see about us today. Just as an indicator, those things seem to have proceeded times of rapid change in the past, in almost every culture in history. They may be indicative of a similar process at work in our own culture.

Equally important is that there have been some fundamental shifts in our time that separate us from the rest of our culture not too many years ago. One, is that we're in the process of making some important and fundamental changes in our energy sources. Every time a society has undergone a shift in its energy source, both in its quantity and type of a fundamental source, the basic nature of that society changes. I mean, it's an old systems axiom that you can't do just one thing. When you really alter one fundamental element, like its basic energy source, everything else readjusts in the end to take account of that. When we moved from a nomadic culture to an agricultural society, from an agricultural society to a wood based society, and then finally to a fossil, and now eventually moving away from fossil fuels again toward something else in the future. When those major transitions of the sort that we are now in the first stages of take place, many other things change simultaneously.

Next, the scale of our society is vastly larger than any society in human history. There's just much, much bigger society, and vastly more complex. The U.S. economy is more than twice as large as it was twenty years ago. In the decades ahead it will double again. When that level of activity and complexity take place all kinds of new phenomena occur which were unpredicated -- complex system on the past. Complex systems generate new phenomena that we are unable to predict and understand. Again, when that level of complexity reaches the point which we have already then we are unable to manage, understand and predict the nature of our own change. So it's quite clear that just out of the scale and complexity alone there is a force for sudden and turbulent change. Our technological power is vastly greater than any civilization in history. At its most destructive extreme we can sterilize the planet if we so choose. Less destructively we have all the powers a Faustian superman ever dreamed of. We can bend rivers, we can leap tall buildings, we can do everything that anyone ever imagined we could do. Part of the question is what should we do with that. We have vastly more people on the planet than we have ever had before. Not too many years ago forecasts of the future focused on global populations of five, six, seven billion people. Now we're talking about a minimum in the next twenty-five to thirty years of twelve billion people. That's vastly more people then have ever existed on the planet before. I suggest our condition changes fundamentally when we have that many people to cope with.

And finally, and perhaps most important of all, our basic belief systems themselves are being challenged. There is a fundamental root to human existence, and that is what we believe the nature of things is -- how the world is put together and what our place in it is. And until roughly the end of the last century there was a kind of dominant myth, one that had changed about the time of the Enlightenment and the time of what was called the century of genius, the time of Newton, the time of Descartes, the time of Leibniz and so on, that led to the modern revolutions of our time -- the revolutions that started this country, the revolutions of France, ultimately the Marxist revolutions in the Eastern parts of the world. That world view was based on a scientific world view that organized our perceptions of how the world is put together. Long about the turn of the century, that world view began to crumble. That is, under the onslaught of quantum mechanics, under relativity, as we began to learn more about the nature of DNA, as we began to learn more about the nature of evolutionary processes and so on, we've come to find that our fundamental scientific world view is itself fragmented. The basis of our metaphysics, the basis of our human understanding of our place in the world is itself now fractured. And there is nothing to replace it yet. There are the early of a coming together of a new unified world view for science, but it isn't there yet. And in the face of that, that fundamental sense of loss and confusion that we see and underlying our incoherent values is not at all surprising, because there isn't any fundamental basis upon which to derive those values. So I suggest that there are a number of indicators that we are in a period of fundamental change, and those are that those traditional indicators of social change themselves are shifting, that our change in energy source, the change in scale and complexity, our technological power, the numbers of people and the nature of our fundamental world view itself is shifting.

Finally, in that respect, the number of social movements around the country today, taken independently they seem to be simple fragments, but let me draw you back a few years to the Chicago Seven trial. And you all remember what the Chicago Seven trial was about -- those were the folks who ostensibly conspired to bring us the riots at the Chicago Convention. There was a problem with the conspiracy trial. Conspiracy wasn't seven people. It was thirty thousand people. It was indeed a conspiracy, but it had no single head. Social movements have changed. Social movements no longer are simply organized the way military operations are organized, with a commander-in-chief, with one person at the top, and if you find that one person you know who's in charge -- nobody's in charge. There isn't a single body in charge any longer. And as a result, those movements appear to be chaotic and disorganized. But in fact there's an underlying set of values and premises that cut across many of the different particular movements which are organized into what appears a relatively coherent pattern. The particular organizations that manifest them may be unstable and short-lived, but the movement as a whole is very real. The environmental movement is a good example of that phenomenon at work. There are obviously some long-lived organizations that are still in business and will be in business for a long time to come. But many short-lived coalitions tend to be the most significant organizations that operate in particular issues to affect particular places and times. So the nature of political movements themselves has shifted. Well, all of that suggests to me that that long term trend of Western civilization is up for grabs. I don't know whether it's going to go on or not. It may in itself be shifting. Toward what direction remains unclear. We've given some thought to that and I want to say a little bit about that.

One aspect of it is a change in the meaning of nature itself. Environment literally meant "other" -- that thing which was outside. And there was the human environment and there was the natural environment. And to mediate between us and the natural environment we developed technology. To mediate between us and the human environment we developed politics as our two particular tools for dealing with our natural and human environment.

Well, that conception of environment and nature may be an outmoded one. That conception of nature was developed when the people, the things we had to deal with were saber tooth tigers. Last time I had to deal with a saber tooth tiger was a long time ago. My Buick Le Sabre on the other hand is something that is more of a problem today. What I suggest is that environment itself has shifted. Our tools, politics and technology themselves, have now become part of our environment. That is, they are a new kind of nature. And that for most of us as individuals, the natural environment we have to begin to cope with are things like power plants, dams, highways, automobiles, computers, government agencies that spy on you -- that's a part of the natural environment that we are now coping with -- and that becomes the more germane environment for most people in civilization today. So the meaning of nature itself -- one might call it now not Mother Nature but perhaps Stepmother Nature -- has itself perhaps shifted. And we have perhaps a more ambivilent relationship to that new kind of natural environment. And we've learned something about that natural environment in studying the old nature. We've learned that we don't have to leave nature exactly as we found it, because nature isn't that all that good all the time. I mean we've all suffered under hurricanes, tornadoes, out here we worry about earthquakes, nature is not all that benign all the time. On the other hand if we change it too much we'll pay the price. We've learned that again and again. And finally we've learned that the metaphor of conquest is an inappropriate metaphor. We never conquer nature. My wife is a mountain climber, and there aren't many women mountain climbers so she climbs mainly with men. And it's only men who talk about conquering the mountain. Women climbers don't tend to talk about conquering the mountain. They just want to be there and be open to the power of the mountain and when they left they have no illusions about who's in charge. Well, keeping in mind that shift in the meaning of nature now, and by the way those arguments about the meaning of nature are found very eloquently in a remarkable book called Many Dimensional Man by James Olgivey, its subtitle is "Decentralizing Self Society and the Sacred"...

Let me contrast now two very different perspectives on the environment and on nature. And what we see then is embedded in that shift in the long term trend and the breakdown of that trend is a shift in perspective -- from what I'll call Perspective One toward Perspective Two. Perspective One sees nature as primarily a resource, something for us to use. Perspective Two on the other hand tends to view most of our natural environment, including our new natural environment, as reasonably sacred, that is as something to be valued in itself -- having intrinsic value.

Second, Perspective One sees us as somehow different from nature -- that is we are divided from it. The Bible even says we are given dominion over it. We're not of it, it is a partition between us and it. Perspective Two on the other hand focuses on wholeness -- sees us in our context. Perspective One talks about dominance over nature -- conquest. Perspective Two on the other hand focuses on nurture. Perspective One focuses on the issue of management and control -- how is that we can adequately manage the natural environment so as to control it for our own purposes. Whereas Perspective Two acknowledges the unpredicatbility of that environment. It continually does rather perverse and unpredicatable things to us. Perspective One focuses on efficient use -- best use, most efficient use. Perspective Two on the other hand focuses on the concept of caring. Perspective One sees technology as dominant over nature whereas Perspective Two sees that technology is now included in our new nature -- our neo-nature as it were. And finally Perspective One focuses on the symbols of wealth, once resources then the symbols of those, dollars. Now Perspective Two comes back around to the things of wealth themselves, the stuff of the ground, the soil, the air, health and so on.

Now what we suggest is that the Modernization Trend and its break--the Modernization Trend is associated with Perspective One and its break may be associated with Perspective Two. And those issues of environmental values that seem to plague us so often today are embedded in those two different perspectives. And they're not being dealt with at the level of should it be more or less efficient, should our use be of this sort or that sort, but at that most fundamental level I tried to suggest earlier -- the level of diagnosis, the level at which we think one has to look at to see the long term direction of our society.

One other factor that one must consider here that's important in the years ahead, is the impact of what we think is one of the most important social changes in the next ten, fifteen years, and that's the impact of the women's revolution.

It's not surprising to me to see predominantly men in this room. Ten or fifteen years from now this room will not be filled predominantly with men. We men have, I think, a misunderstanding about the nature of the women's movement. I want to draw an analogy to the civil rights movement. The civil rights movement in the '50s was by and large an elitist leadership oriented movement who's primary goal was to get Blacks accepted into white society -- give us a place in your communities, give us a place at your table, give us a place at your jobs and schools and so on. The real impact of the civil rights movement in the '50s was not to win that victory. It was to awaken in a generation of people a consciousness of their actual status in society. The consequence of that change in consciousness was to create the Black movement of the '60s who's primary goal was now to get white society to accept Blacks as Blacks. It is you change to accept us for what we are not force us to change to be a member of your society. I'm not saying that succeeded, but that was the thrust and change of that movement. The women's movement it seems to me is following a similar pattern. It began a primarily as an elitist movement of women who spoke to a relatively small number of other women who's primary goal was to get accepted into male society. The real effect of that movement on the other hand was to awaken in a generation of women young and old consciousness of their stature in society -- of their second rate role as citizens. I suggest that there will be a profound consequence of that because unlike Blacks they're not ten percent of the population, ther're a majority. Like it or not, you know, they're most of us. We're the minority here. And they will have their way, one way or the other. And there isn't anything we can do about that. They're going to have their way. We have this misconception see, about men and women. Most of us have taken enough mathematics to know that there's a difference between equality and identity -- two things can be equal without being the same. Well I think its kind of obvious when you say it that men and women are different. And we try to pretend by and large that they're not different. But they are different. They may be equal, but they're different. And we have this image, we men, that we're going to unplug a male module in our office or our company or our government agency, and we're going to plug in a female module and nothing's going to change. Wrong. It's not going to be like that. Again, as with energy sources, when you shift the fundamental sexual roles and the psychological basis upon them, everything else changes to accomodate. And it's a pervasive and fundamental change that I'm suggesting that is going to go on here. The values that underly feminine psychology, I suspect, are very different than the values that underly male psychology. And what happens in our particular organizations and our particular institutions and the goals and values that those institutions embody and head for will be fundamental, and the change isn't going to be that easy, because it really is as fundamental as I tried to suggest all of these changes are. For us, as men, it's going to be real hard. We're going to have to learn new ways to communicate, new sets of goals, new sets of perceptions, new ways to organize our activity. And it's going to be a time of great turbulence and difficulty for most of us. It will make our organizations less efficient probably in the short run. In the end I hope the change will positive. I don't know what the outcome of that is, or how quickly it will proceed. But it's underway, it's inexorable and we aren't going to anything to stop it.

Okay. I'm just looking at my clock here. Let me see if I can summarize where we are. We've been as a civilization on this pattern for a long time -- this pattern of modernization. The years ahead, I think, are a time of great uncertainty because the very fundamental nature of our civilization itself is being challenged. It's being challenged by the change in our condition, by the change in our energy sources, by the change in the basis of value, by the change of the people who are significant and dominant in our society, the change in sexual roles, all of which argue that the value bases upon which we think about the future make our projections and forecasts themselves are very much open to question. I really wonder whether the future, the next ten, twenty, thirty years are going to be very much like at all most of the conventional forecasts that have been made upon which most of the economic, energy and resource forecasts that underly policy are made.

I suggest that we are in a time of much greater uncertainty than any of us have faced. It makes making policy decisions very difficult. It makes allocating resources to research very difficult and I don't think we are going to escape our uncertainty very shortly. We are unable to define or adequately -- there isn't any particular set of scientific tool that we're going to apply that's going to eliminate this. This isn't something that's going to go away by more careful study. That uncertainty is fundamental to our times, and isn't going to go away in the next few years. It's with us and it's going to stay here for a very, very long time to come. Okay. Thank you very much. And I'll open it up to questions, challenges or arguments at this point.

QUESTION: You might make your projections. Where are we headed? You dodged the uncertain point. Where do we go from here? You're projecting uncertainty.

MR. SCHWARTZ: Okay. I'll give you my opinion. Nothing more than that. Okay, take it as an opinion. I think the next ten, fifteen years going to be some pretty crazy times. If the '50s were a time of relatively smooth affluence, the '60s were a time of activism, the '70s have got to be a time of insanity. Any period that's characterized by Watergate, punk rock, Jonestown has got to be a pretty insane time. You know, when these are the dominant events of the decade it's quite clear that there's something else going on that we don't really understand. So if anything characterizes where we are headed it is that fragmentation and fracturing of our basic social and cultural fabric. What it means is a time of great confusion, disorder and uncertainty. I suspect that what that means is in real terms economic growth slower than one might have anticipated otherwise. That progress along many different fronts, especially in energy, will be much more slow than anybody imagined, development of coal for example is a good case in point. We looked at nuclear energy, and we said "could you have anticipated the nuclear movement that's arisen in the last few years?" And we discovered that you could have foreseen much of what's occurred in the last five or six years as early as 1953, '54 -- that all the seeds were there and all the information that was needed to forecast it was already present. We think that most of the forecasts about development rates for energy sources are way out of line -- they're exercises in fantasy. As a consequence what it means is that many of our projections and programs themselves are going to be considerably more turbulent and chaotic than we have ever imagined before. This is especially true because the nature of political power itself has changed in our time. Nietzsche said God was dead. And what he meant by that was that the role that God plays in society is dead. Jay Olgivey says the presidency is dead. And I suggest that the role that the presidency plays is the role that God once played and they're both dead. Our image of political power is that of a copplemeister, playing a tracker-action organ. A tracker-action organ is that great big organ with pipes and keyboard right, and you sit there at the keyboard and you push this key and the right, through a complex set of linkages big pipe sounds, and out comes a note, and another key and another pipe, and so the president sits at his keyboard playing his keys and a harmonious tune comes out the end -- policy, programs, national thrust and so on. The trouble is that someone disconnected the keys and reconnected them in funny ways. And he pushes this key and that note sounds, and pushes this key and that note sounds. And cacaphony results, not harmony. As a result the ability of executives to implement policy and have real power work is fundamentally altered. Power to me means the ability to realize intention -- that is to get what you want done, done. Now I suggest the President, and most corporate executives and so on have a great deal of impact. When they do something all kinds of things happen, but it bears very little resemblance to what they wanted to have happen. And, now we have a tendency with commodities to say if it went from one place, where did it go to? The trouble it kind of went like that. It's like smoke, and I don't think it went some place else. It isn't that somebody else is in charge, nobody's in charge here. I don't think anyone is in charge any longer. And as a result the ability at a time of great turbulence to marshall resources to accomplish particular ends, like energy development, is extremely limited. And as a consequence of that a time of turbulence and economic disorder seems reasonably probable to me. That's my answer to your question.

Yes sir.

QUESTION: Do you expect to see a growth in political authoritarianism in the West which results in a breakdown in society? A perceived breakdown in society (inaudible)

MR. SCHWARTZ: I think it's a real danger. I'm not so much worried about big brother in the traditional image of a dictatorship. Those are relatively easy to recognize, and our systems are pretty well adapted to trying to prevent those. Those are fairly unlikely I think. Far more likely it seems to me, is the pervasive encroachment of all kinds of constraints on individual choices. It is when the institutions become increasingly distant from the people who give them ligitimacy, when our choices are increasingly trivialized and our sense of control over the meaningful decisions in life are increasingly diminished, then we're moving into an inherently authoritarian direction. I was engaged in a debate not long ago with a man on energy policy. And he said one of the great crimes that was happening in energy policy is that we were going to be constrained in our choices of air conditioners and washing machings and so on. And I said I don't see very much authoritarian about that. I think what they were talking about when they talked about freedom of choice was with gods and political systems and economic systems, not washing machines and breakfast cereals. And we have too often equated and sacrificed fundamental freedoms to obtain trivial freedoms -- freedoms of choice of washing machines and breakfast cereals, when that didn't seem to be at issue at all in the revolution that founded this country. So I think part of the issue then is discerning the what the real meaning of free choice and non-authoritarian decision making amounts to, and finding ways in which we can begin break up the system a little bit that begins to arbitrarily constrain more and more of our choices.

Yes sir.

QUESTION: The comment you had about nuclear energy being -- I mean the results, the effects of it were detectable as early as '53 (inaudible) and it was a year or two before it was accepted as a viable energy source. What were the indicators that were ...

MR. SCHWARTZ: What I meant to say was the nuclear opposition, not the effects of nuclear power plants or anything like that, but the nuclear opposition, all right, was the ... all of the elements of that were in place a long time ago. What we looked at were things like many of the scientific papers that were published at the time, various organizations and movements that were already growing at that time, and what their particular attitudes were, and what the particular conditions and structure of the nuclear industry was that was being created -- in particular its vulnerability to government policy. That is, that it required the Price-Anderson Act and it required the AEC's existence to be a viable entity.

And when you begin to put together some of the long term impact of such social movements of scientific uncertainty and dependence upon government policy you see an industry that is inherently vulnerable in the long run.

Yes sir.

QUESTION: (inaudible)

MR. SCHWARTZ: That's right.

QUESTION: (inaudible)

MR. SCHWARTZ: Well, here in this state we have a "gov" who I think would like to be the man on horseback, and to some extent he is one in our own state. But he's already learned, the hard way, last June, what the limits of his own power were in a state of only twenty million people. A clear majority, sixty-four percent of the voters, got up and said "no, you can't have as much of our money anymore as you used to get". And he got that message loud and clear, as everybody's learned around the country. And so I wouldn't be surprised to see lots of folks coming along on horseback, but they're going to be little horses, not big horses. And they're going to be more like ponies rather than horses. And I don't think they're going to have the impact that ever had before. They may try. I'm not saying that people won't try. But I don't think that there's going to be that kind of ability to realize it. Perhaps. I mean that's always a possibility. I don't mean to discount it altogether. It could happen. I consider it highly unlikely in our society just because of its complexity.

Maybe somebody at the top ... look, a few years ago we talked about the imperial presidency. Nixon, whatever one may have liked or disliked about his politics, tried at one point to be a reasonably imperial president, and found again and again that everything that he tried to do was thwarted. We just saw recently that the memorandum that he put out on trying to control PBS, you would think he would be able to do something small and simple like that, and he couldn't even get away with that. The system is just really gotten out of the control of executives and executive authority. So he is really unable to exercise that kind of power despite his own myth and fantasy. Can anybody master the Civil Service? I think Jimmy's trying and ... without much luck.

Yes sir.

QUESTION: Do you suggest that these forecasts are more or less inevitable, that we cannot be masters of our destiny? What do we need to do to effect the kinds of change that we need?

MR. SCHWARTZ: I think we are in a sense the masters of our destiny, but I...and forecasts are never inevitable. There's always surprise and there isn't ... and there's also always misunderstanding. Our picture is always incomplete. There's things that I've missed. So there's nothing inevitable, about what I've said. More important, in the study we've been doing for the California Energy Commission what we have come increasingly to see that in the long run, in part because of the nature of the shift in political power, that if anything, power is moving away from large scale central institutions back toward individuals -- a diminished power to be sure, but a power nevertheless, and a power to choose how one lives, and have the consequence of those personal choices about lifestyle, life way, values and so on ultimately be realized in social, political and economic structures. Those are long term processes and it means that our fantasies of power are just that -- fantasies -- that we are unable to realize what we wanted to at one time.

Thank you very much.

EPRI LOW COMBUSTION NOx RESEARCH

by

Donald P. Teixeira
Electric Power Research Institute

A copy of Mr. Teixeira's paper was not received in time for the publication of this volume.

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PANEL
SHORT-TERM NOx STANDARDS

The Panel Discussion on Short-Term NO_x standards was recorded and transcribed for inclusion in this volume.

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SHORT-TERM NOx STANDARDS PANEL

MR. ROBERT E. HALL: The last event of the day, the last official event of the day. I think we are very fortunate today to have what I am sure is going to be a very interesting panel discussion. I feel like this is one of the key special features of the meeting and, as it turns out, a very appropriate topic for this meeting.

We have arranged a panel discussion on the short-term NOx standards and, as you well know, depending on what level is finally selected, this may or may not have quite an effect on the work that everyone in this room is involved with.

We are fortunate to have with us today four distinguished members on the panel and, I think, a pretty good cross section to give us an overall view of short-term NOx standards.

Stan Coerr represents the Environmental Protection Agency. Stan is in the Strategies and Air Standards Division of the Office of Air Quality Planning and Standards of EPA. That is located in the Research Triangle Park area in North Carolina. Those offices are actually in Durham.

Stan is the national program manager for the NO_2 National Ambient Air Quality Standards, and has also worked on the lead ambient standard. Stan has been with EPA for the past seven years. He has a masters in public affairs from Princeton in economics and public policy, and a bachelor's degree in economics from Williams College.

Our second panel member is John Wise. John represents the EPA Region IX office, which is located here in San Francisco, and he will discuss the standard as it affects the Region in coordination with the state agencies. John is the Chief of the Planning Branch of the Air Hazardous Materials Division of EPA Region IX.

He got a BS from the University of Colorado in civil engineering and business administration, and from Stanford he received a master's in engineering economic planning. He has been with EPA since 1971 in the Water Quality Management Planning area, the construction of waste water treatment facilities, and air quality management planning. The air quality management planning is the most recent area.

Our third member of the panel is Frank DiGenova, who is with the California Air Resources Board, and California has had a short-term NO_2 standard for some time, and Frank can give us some input about their experiences and, depending on what EPA comes up with for standards, this may or may not affect the state standard.

Frank received his BS in physics from the State University of New York, and his master's in environmental science, specializing in air resources, from Rutgers University. He has also taken courses in atmospheric science at the University of California at Davis.

Prior to working with the California Air Resources Board he worked for three and a half years for the State of New Jersey in the Bureau of Air Pollution Control, Planning and Evaluation Section. He joined the Air Resources Board about two years ago, and since then worked in the area of control strategy development for stationary energy sources. In particular, he has worked with SOx, NOx, mainly related to power plants and refineries. He has been heavily involved with the development of NOx control strategies in the LA basin, especially systemwide control of power plant NOx emissions, and today will discuss the EPA standard versus the California standard as it relates to their experience.

The fourth member of the panel, to give an overall perspective, and not have it completely overloaded with government and regulatory people, we have asked Vincent Mirabella to represent industry. He is with Southern California Edison Company in Rosemead, and is the supervising research scientist in the R&D Department.

He received a BS in meteorology from Florida State, and an MS in meteorology from Penn State. His present responsibilities involve air quality impact analysis on new and existent power plants, and evaluation of proposed rule making.

At this time I would like to turn the panel over to Stan Coerr, who will chair the panel, and the plan is to allow each speaker to go through his presentation without questions, mainly because a lot of the questions for one speaker may be answered by another, so we would like each of the speakers to give his presentation, and then we will open, after each of the four have given their presentation, we will open it up for general discussion.

I would like to point out, since we wanted this panel discussion to be up to date to the minute as much as possible, we did not attempt to put it in the preprint. For that reason we have a stenographer who is recording and taking notes on the panel discussion, but in order to avoid creating any problems with discussion, or holding anyone back from open discussion at the end of the presentations, she will not record the questions and answers.

Stan?

MR. STANTON P. COERR: Thank you, Bob.

First of all, the national ambient air quality standards are denominated as nitrogen dioxide. The control of ambient NOx, as far as the standards themselves, are described as nitrogen dioxide.

(The following part of the presentation was accompanied by slides.)

MR. COERR: I want to run briefly through the status of our program to consider a short-term ambient air quality standard, and also to consider revisions of the long-term standards. What we are doing here is following instructions from the Clean Air Act, so I am going to go through each of the principal provisions of the Act which are controlling what we are doing.

I will also talk about our schedule and touch on a couple of the many issues that are involved in the standard-setting; on what the law requires for the standard and on the impact of the standard large point sources.

I won't ask you to read all the small print, but I would like to point out that what seems to be controlling our efforts in preparing these standards is four or five provisions of the Act.

First of all, the Act is very specific that the Agency should create scientific criteria to serve as the basis for the standard. The regulatory side of the Agency can't move ahead to propose or promulgate the standards until the research side is finished with criteria documents. They are in that phase right now.

The Act is specific that we should develop criteria for a short-term standard, and it also mentions that we should be periodically revising our criteria for long-term standards.

For the NO_2 standards we have combined these two exercises into a single criteria document, and this may have added to some of the confusion in reviewing various drafts of criteria documents. We originally had a document describing only criteria for a short-term standard, but the current external review draft is a combined document.

Following development of air quality criteria, section 109 of the Act directs the regulatory side of EPA, to go ahead and set a short-term standard. With a sort of curious turn of phrase, it says that we are to do this unless the Administrator finds there is no significant evidence that such a standard for such a period is requisite to protect public health.

The key point here is that, in sort of this negative-finding kind of way, if we have health information that a short-term standard is required, then we are to proceed to propose and promulgate.

You might notice there are some dates in the Act. We are not going to make those dates, and I will get to them again in a minute. There is a list of reasons why we are not on the congressional schedule. One is that there are a lot of things in the Clean Air Act of 1977, and we are sort of starting at one end and getting to the other, but we can't do them all on schedule.

Section 109(d) also asks the EPA to look at all of our existing ambient standards on a five-year cycle, and so, as we were considering the short-term standard, we were overrun with the requirement to review the existing annual standards set in 1971, so now we are doing both at the same time.

Section 109 also took from EPA what we used to run as an internal EPA science review group The Science Advisory Board, and established a Scientific Review Committee, with a congressional mandate. So, one of the things we are going through now is to review both the criteria documents and some of the other documentation we are developing, with this new scientific review group. I think some of the people in this room have had an opportunity to testify or to observe those meetings of the Clean Air Scientific Advisory Committee.

A very key point, when we are talking about the impact of an ambient standard, is the division of responsibility that Congress came up with. My office is responsible for developing a national standard, which we present to the administrator in the form of alternatives which he has decisions on. But under the Clean Air Act the implementation of the standard is delegated to the states. Their plans have to be approved by EPA, but it is a little hard, as we develop the standard itself, to know what plans will be forthcoming from the states, and exactly what kind of impacts they will have.

There is a great deal of discretion in this SIP process, which I think is something that the panel members will discuss, and this allows some latitude in what kind of impact the standard may have on power plants because of how they are treated in the SIP process.

The last point, once again, is that the single focus, or the basis for the level of the standards, is health effects. This is not to say that the standard setting is simple, because the health information is complicated and not always definitive, but we are not, under the law, to use either economic or technical feasibility as a primary criterion for the standards.

We do however get into discussing what might be the impact of a proposed standard. We are required to prepare economic impact statements and environmental impact statements. We do this, but we are not setting up an array of costs and benefits and choosing the standard in that sense. We are constrained in terms of the health information presented in the criteria documents, one of the reasons why that process of the development of criteria documents gets so much scrutiny from industry and ourselves.

This is the current schedule for the NO_2 standards.

We put out a criteria document draft the end of '78. This draft was reviewed by the Scientific Review Committee on January 30 and 31, 1979. The Committee asked that certain portions of the document be revised, and that is now being done. We expect that these revisions will be complete by the end of May, 1979.

Using that document as a basis, we are then going to proceed to develop proposed regulatory decisions on the short-term and long-term standards, and we hope to have this in proposal form by October, 1979. We normally run about six months between proposal and promulgation, and so, barring unforeseen delay, we would be promulgating in March or April, 1980.

It is important to point out that we have not yet formally made any finding as to whether a short-term standard is necessary, or whether a revision of the long-term standard is necessary. I have my opinions, and other people have other opinions. It simply hasn't yet been elevated to the senior management of the Agency.

I am not going to discuss here the considerable number of issues in the health effects information, simply to say that it is an issue, and we are getting a good deal of comments, and we expect to get some more.

The process for us is to identify what we consider to be the adverse health effects associated with ambient, or potentially ambient, levels of NO_2. There are two effects of concern. One is the reduction of pulmonary function, similar to ozone, and, again like ozone, a decreased resistance to respiratory infection.

We are concerned in this not to necessarily protect the most sensitive individuals, or esoteric group, in the population, but we do look for general subgroups within the population that are particularly sensitive: asthmatics; children; the elderly; people with a preexisting respiratory condition.

We will also be trying to find any information from clinical studies or epidemiological studies about what kind of period of exposure is significant. This is particularly important to NO_2 because Congress left us the latitude to set a short-term standard of one to three hours. From our initial examination it is going to be difficult to find information that would tell us which of those, the one or the three hours, would be the best way to go. This point does have an impact on point source modeling.

The last fuzzy area in the health area is the concept of margin of safety and acceptable risk, and there are plenty of issues in this; I am sure that these issues will be discussed as we get the final criteria document and start looking at the standard.

As I have stated before publicly, our general range of consideration for the NO_2 short-term standard is in the range of .1 to .5 ppm. This is where the center of attention is. A few associations have advocated a standard as low as 0.15 ppm. Representatives from industry have stated publicly that they believe that there aren't really any serious effects under .5. There is a polarization of scientific opinion on this.

Our second big issue in this particular standard is that it is a complicated standard from an air pollution control point of view. Control of NO_2 must be directed at control of the precursor NOx, which turns into NO_2. There are quite a number of things that affect how this conversion happens, no one of which seem to be consistently the controlling factor for all parts of the country or even within the same area on the same day.

There are variable rates for the transformation, and then you have the time lapse between the emission and the impact complicating things. We have had made a couple of different approaches as to how we might unscramble the relationship between emission control and the ambient level, and these are described in our draft environmental impact statement and other documents that we have available, and anyone who wants to know what we have done so far can talk to me afterwards, or write to us and we will send them what we have.

One particular point is that we are going to have a very interesting problem in allocating -- we are not going to have the problem; the states in developing their plans will have the problem -- allocating existing NO_2 level back to the several different sources which might be contributing; point sources: automobile traffic, and general area sources.

Again, these contributions are probably going to be variable, and depending on a number of factors. We are also concerned that control measures to achieve the oxidant standard will affect what we are trying to do to attain the NO_2 standard, and, where we start controlling NOx, there is an impact on the oxidant control program.

Another range of issues is not so much the impact of the primary standard itself, but what kind of concerns the indirect impact of the standard on other regulatory programs such as new source review for nonattainment areas, and prevention of significant deterioration.

I can state fairly categorically that we haven't bitten the bullet on how we are going to handle the PDS approach to NO_2. We have been thinking that we would not necessarily adopt the increment approach as we did for SO_2 or TSP. This is an area in which comments would be very welcomed by the Agency, if anybody wishes to offer them.

Again, when we get right down to what do these ambient standards mean for large point sources, such as power plants, I want to point out very strongly that the impact is a dual function of the level of the standard, the SIP regulations, the guidelines we will propose, and finally the SIP plans that we developed by the states. There does tend to be, in my experience, a good deal of discretion in that process, which allows you to proceed to achieve a standard with varying degrees of economic impact. We are always very interested in being able to achieve whatever standard we come up with with the least possible economic dislocation, and we would welcome comments on the guidelines and the regulations on the SIP process as much as we would on the standard itself, particularly, I think, in the area of point source modeling, where we are dealing with a kinetic pollutant. We would also appreciate any empirical information you have on air quality data.

This concludes my remarks. We will save questions until the end, and now I will hand it over to John Wise, from EPA's regional office.

MR. JOHN C. WISE: Thank you, Stan.

Is everyone in the audience able to hear me okay? I am always intimidated by a room this vast, and a speaker system that projects outward is always welcome.

As Bob Hall and Stan have indicated, I am from the regional office of EPA here in San Francisco, and I bring to the panel a perspective not only of the regional office as opposed to headquarters, for example, but also a perspective -- some may say bias -- of the planning aspects of the Clean Air Act.

In San Francisco, I am personally responsible for managing the state and local planning process that leads to the development, adoption and implementation of control strategies in the state implementation plan to attain any national standards.

Now, many of you may be from this end of the country, but it is always interesting to point out that Region IX, with our office here in San Francisco, actually manages a rather vast geographic area, including the mainland states of California, Arizona and Nevada, and the Pacific Island states and territories of Hawaii, Samoa, Guam, and the Marianas Trust Territory, of limited diversity of activity, but of course a short-term NO_2 standard may or may not affect all of these particular areas.

The current activities in our regional office are almost entirely preempted at the moment with the review, evaluation or approval of the '79 revisions of the State Implementation Plan. Many of you may be aware that the Clean Air Act of 1977 mandated there be a planning process for areas that were designated non-attainment, that plans to demonstrate such attainment of the national standards were due to be submitted by the state by January 1, 1979, reviewed and approved by EPA by July of 1979, with a demonstration of attainment of the standards by no later than December of 1982 and, for certain circumstances, an extension of up to five years, to 1987.

In any case, that work load, as a priority matter, has virtually occupied 150 percent of our time in the regional office, and accordingly, we have watched the progress of Stan's group in OAQPS headquarters with the development of standards almost with one eye over our shoulder.

Stan provided some statutory rules on health effects information, as well as highlighting a few issues. The purpose of my remarks will be to bring a regional perspective to the short-term NO_2 standard, and to give you a generalized assessment of potential problems in the region and a sense of the implementation scheme that we will operate under.

First of all, just as a reference point, it may be useful to consider the existing annual standard for NO_2. In Region IX there are only two areas that are currently classified as a non-attainment for nitrogen dioxide. These are the Los Angeles area (sometimes known as the South Coast Air Basin), and the San Diego area.

For those particular areas, a revision to the state implementation plan is now under way, and those who are from L.A.

will recognize that as the AQMP, Air Quality Management Plan, which has been very much in the press and very much in the public view. The Air Quality Management Plan will attempt to demonstrate attainment of the ambient standard of NO_2 by 1982, which, of course, is the statutory due date.

Because of the nature of the problem, which in L.A. is largely related to mobile source emissions, and certainly stationary sources as well, attainment by 1982 is going to be exceedingly difficult, if not impossible. Now, this may have some ramifications for a short-term standard, and we will get into that in a moment.

Looking now at the potential short-term national ambient air quality standard for nitrogen dioxide, assuming, of course, that we do have one, and assuming that it sets a level within the range that Stan gave, we have gone back and reviewed all of our data records, ambient monitoring data, for the 1976-77 period, and assumming a midrange point of about .25 parts per million for NO_2, it appears that the following areas may have some problems: Phoenix, Arizona; Los Angeles, continually; San Diego; San Francisco; and San Jose, which is actually part of the San Francisco metropolitan area, but occupies the air basin south of the Bay proper.

The problems, of course, are potential, and based upon a very cursory review of the ambient data, it would be premature to make any firm conclusions about the nature of the problem, but I think that we can generalize to the point of saying that those areas that are likely to have short-term NO_2 problems may be characterized by, number one, large urban areas with a variety of NOx sources and a large hydrocarbon emission rate. This would characterize most of the major metropolitan areas, at least in this region.

Another general characterization may be areas with major NOx stationary sources, such as power plants, which also have high ambient ozone concentrations.

The many urban areas in Region IX and, of course, elsewhere throughout the country have high levels of oxidants, or ozone, as we now commonly call it, based upon our new revised standard. Many of our areas do have high or elevated levels of ozone, which contribute to the NO_2 problem by the reaction kinetics and the chemistry of the situation.

In Region IX, and especially in southern California, the problem, as I indicated, is predominantly mobile source related, although major power plants and other stationary sources are contributing factors.

The application of reasonably available control technology, which we call RACT, which applies to existing stationary sources, the application of pre-construction review and issuance of a permit for new sources, and the benefits which will ultimately be realized from the federal motor vehicle emission control program, may all play a part in controlling emissions to attain the short-term standard. However, there are multiple uncertainties involved in that.

To the extent that mobile sources are involved, we can anticipate that we are going to need some long lead times which are necessary to phase in a fleet of cars which meet emission limitations.

We are also going to need some relatively long time frames to develop and implement transportation control measures, which may change the vehicle use patterns, and vehicle driver behavior.

Now, of course, in California -- and this only applies to California -- we do have emission limitations more stringent than the federal, significantly more stringent, and this will lead to an accelerated schedule of compliance.

The problem of NO_2 attainment, however, with all the uncertainties already given, is further complicated, as Stan indicated and, I am sure, other speakers will also elaborate on, is further complicated by the chemistry of the situation. NOx is a very important precursor to ozone formation, but reducing NOx as an independent control strategy may actually increase ozone concentration, if the ratio of reactive hydrocarbons to NOx is relatively low.

Now, you will notice the generalities in that statement. I can't be more specific as to what the exact ratio is or should be to prevent this unfortunate Catch-22 for control strategies. It is an area which warrants considerable further investigation, and will definitely be needed if and when we actually move into an aggressive implementation plan within the short-term NO_2 standard.

The characterization of the problem is necessarily general, primarily because of the press of other work, and the schedule for developing the new standard. We really haven't done a thorough investigation of the real impact on the region.

In any case, if and when we do select a standard, we will go through the process of a formal proposal in the Federal Register, solicitation of public comment, normally over a period of 60 to 90 days, thereafter considering the public comments, making the appropriate revisions, and ultimately, if necessary, promulgating a new national ambient air quality standard.

Now, once the new national ambient air quality standard is promulgated, this triggers a whole series of events, which is where I become involved, and that is, once the promulgation occurs, the state, which has the principal responsibility for developing the state implementation plan, now has nine months to prepare a SIP revision which will demonstrate attainment and maintenance of the new national ambient air quality standard. Nine months is not a lot of time, of course.

But to further complicate the issue, once the state submits the revision of the state implementation plan, and EPA approves it, then there is a period of three calendar years, within which time we must demonstrate attainment with the new national standard.

So the trigger point is promulgation of the standard. We then move into an accelerated planning process, which will result in a revision of the SIP, or state implementation plan, with then a three-year period following to demonstrate attainment and maintenance.

Now, the regional office is engaged in a whole variety of planning activities which will support this effort, if and when the national standard is actually promulgated. We will be providing grant assistance to the state air pollution control agencies and local air pollution control districts. To give you a sense of what we had already programmed for 1979 -- and of course this schedule demonstrates that most of this will now occur in 1980 -- for Arizona we budgeted a nominal fee of $22,000 for NOx control strategy development, emission inventory work. In California we budgeted almost $100,000, $60,000 of which is allocated to the South Coast Air Basin. For Nevada we budgeted a minor sum of $8,000, and for Guam and Hawaii, $2,000 and $5,000 each.

Now, clearly, this is not a lot of money, but we anticipated that it would provide seed funding for the beginnings of an NOx control program, which would ultimately, if everything happens on schedule, result in a SIP revision for the new standard. Clearly, in 1980, which is federal fiscal year 1980, we will be programming more resources to help state and local governments deal with the new standard.

In addition to that, assistance will also be provided for monitoring assistance, the siting of the monitors, the technical requirements of the monitors, the reference methods, the site, location, quality assurance and all of those associated activities. At a minimum, we will try to locate two monitors in each of the areas, although in many cases we may need more to get an accurate description of the ambient situation.

We will also be developing, refining and, hopefully, applying our modeling expertise to assist state and local governments to make that translation between emissions on the one hand and ambient impacts on the other. Of course, it is going to be exceedingly complicated by the hydrocarbon-NOx ratio that we referred to earlier.

Beyond that, there is a whole series of control strategy developments, as I indicated: new source review, reasonably available control technology for existing sources, tail pipe emission controls, transportation control measures, a whole variety and mix of strategies which, hopefully, will result in attainment, and then finally culminating in the process of submitting of the SIP to EPA.

That is the generalized framework, and without being more specific, it is then perhaps most appropriately summarized by the following time sequence. The standards being formulated in Stan Coerr's group will eventually be proposed, go through a series of public comments, be promulgated. That in turn will trigger a process on the state and local levels of revising the SIP, developing control strategies and, hopefully, three years later will result in attainment of standards.

Clearly, for the short-term standard, we are in for a long-term process.

Thank you.

MR. FRANK DiGENOVA: First of all, I appreciate the opportunity to be here today. I am here on behalf of the staff of the Air Resources Board, and I would like to try to describe to you -- Well, the topic of my paper is the California standard compared to the federal standard, and I would particularly like to talk about the L.A. Basin experience, what it has been and what it appears the future is going to be, firstly because that is where the problem appears to be the most severe and secondly because that is the area I am most knowledgeable about.

The areas that I plan to discuss include a review of the national and California standard and comparing L.A. air quality with those standards; an examination of the source of NOx emission in L.A.; and some consideration of what the Air Resources Board views as being allowable NOx emission. Finally, I will try and describe the control strategy approach that the Air Resources Board is taking, and has taken.

To begin with, air quality standards, the national primary and secondary ambient air quality standards for NO_2 are the same, an annual arithmetic mean of 100 micrograms per cubic meter, .05 parts per million, which is not to be exceeded in any year.

The California standard is a maximum one-hour standard of .25 parts per million, which is 470 micrograms per cubic meter, not to be equalled or exceeded. I would point out that it is unlike the federal ambient air quality maximum hour standards, which may be exceeded once per year.

The California NO_2 standard was adopted by the Air Resources Board in 1969, along with ambient air quality standards for oxidants, carbon monoxide, SO_2, H_2S, visibility-reducing particles and total suspended particulates in the Bay Area and the South Coast Area.

You have heard considerable discussion in the past couple of days about the cost and problems of controlling NOx emissions, and I think it is appropriate, in the case of Los Angeles, to talk a little bit about what the air quality there is and has been.

The national and California ambient air quality standards for NO_2 have been exceeded at many sites, and by wide margins, in recent years. For example, in 1977, 12 of the 15 monitoring stations in the basin violated the national standard, with annual averages of NO_2 ranging from about .06 to .09 parts per million, which is almost double the standard.

Also in 1977 the same 12 stations, plus a thirteenth, violated the California standard, with maximum one-hour concentrations ranging from .27 parts per million to .6 parts per million in downtown Los Angeles, more than twice the standard.

Also, these violations of the California standard have been quite frequent at some sites. For example, in 1977 the downtown Los Angeles site, over a period of 11 months, exceeded the California standard on 1973 hours over a period of 54 days, on the average about every sixth day.

I am really interested in talking about NOx as a precursor to NO_2, but I do want to say something about the NOx contribution to nitrates in passing, and also oxidants. In case you are not aware, and those of you who are not from California may not be, the total suspended particulate matter federal and state standards are also violated by a wide margin in the South Coast Air Basin. For example, in 1977 the highest site, Riverside, measured 508 micrograms per cubic meter on a 24-hour basis, and the highest annual site, 146 micrograms per cubic meter as an annual geometric mean measured in Chino. That is more than twice the primary standard.

With respect to oxidants, I would like to comment that the Air Resources Board has received some modeling studies which suggest that NOx reduction will result in widespread ozone increase. It is our opinion that the data we have received to date is inconclusive, because large hydrocarbon reductions which, in effect, would accompany the NOx reductions were not taken into account.

I would like to review a little bit what the sources of NOx emissions are in the South Coast Air Basin. First of all, there are no significant natural sources. We are primarily talking about anthropogenic, mostly combustion-related, sources, and the total emission rate appears to be about 1,300 tons per day in 1975. You might want to keep that number of 1,300 in mind.

About two thirds of that for 1975 was mobile sources. The remaining third was stationary sources, and power plants represented about 13 percent of the total, with other stationary sources representing about 20 percent of the total.

Because of the projected increases in NOx emissions by 1985, the Air Resources Board in July, 1977 adopted the light-duty motor vehicle standard of .4 grams per mile that you have already heard about for 1982 and later model year vehicles.

With the effect of this motor vehicle standard we expect the contribution for mobile sources to decline from about 870 tons per day in 1975 to about 690 tons per day in 1985. However, this reduction would be largely offset by the increase in stationary source emission growth, from about 420 tons per day in 1975, about 33 percent of the total, to 540 tons per day in 1985, about 44 percent of the total.

Recognition of this fact led the staff to the conclusion that further stationary source reductions are necessary, particularly for power plants, which are projected to increase thier emissions from 160 tons per day, again 13 percent of the total in 1975, to 230 tons per day,19 percent of the total, in 1985.

Just how much reduction is needed? The issue of NOx control and oxidant control was addressed in a special ARB conference and staff report in January of 1977, one of the conclusions being that there was a need for stringent further mobile and stationary source control.

In that conference, the monitoring station at Pasadena was identified as a site having a representative mix of mobile and stationary source control, a representative mix of contributions from mobile and stationary sources, and therefore the staff has used Pasadena as the site to design a control strategy, even though this is not the site that has the worst NO_2 air problem. Far from it.

Using a modified rollback that applies credit for expected hydrocarbon reduction, the staff has estimated that the corresponding allowable emissions for the state standard would be 770 tons per day.

There are two points to recall. First, we did not use the highest hour as, strictly speaking, the standards would require, but used the second highest hour. Secondly, we did not consider the worst site. We used Pasadena. The worst site would result in a much lower allowable level.

The overall reduction that would be required in either case is about a 40 percent reduction or, for stationary sources, about 85 percent reduction. In the case of the Los Angeles Basin, it appears to us that the difference is academic since, as has already been noted, we have some pessimism about our ability to achieve either level in the short term. Therefore, it is our goal to achieve the maximum emission reduction that we can, which brings us to the point of what has been done and what we foresee.

All the significant NOx sources are considered as candidates for control. We note that substantial NOx reductions have already been achieved by power plants in the L.A. Basin. Primarily through combustion modifications, reductions on the order of roughly 10 to 70 percent have been achieved at some of the larger power plants. Other smaller power plants have not reached those levels thus far.

If I can go back to the January, '77 conference recommending more stringent mobile and stationary source control, I would recall to you that in the summer of 1977 the Air Resources Board adopted a .4 grams-per-mile limit for 1982 and later model year vehicles.

More recently, about a year ago, the South Coast Air Quality Management District adopted stringent rules for existing and new power plants, requiring 90 percent control of existing units by 1985, and also stringent controls for new units. The ARB staff concurred with the South Coast Air Quality Management District on the need for this kind of control, and the feasibility of it.

Shortly after adoption of that standard the Air Resources Board was petitioned by two utilities in the South Coast Air Basin to review the district's rule, and the ARB modified that rule to provide a couple additions, and I will just touch on that briefly.

First of all is the sytem concept. The ARB adopted the approach of systemwide control, something akin to what you may have heard EPA talk about as the bubble concept, except in our case we view the bubble as an electric utility system.

Secondly, the ARB approach requires the use of least NOx dispatch, that is, loading the system in such a way that low NOx-emitting units come on line first and remain on the longest, and the very dirty NOx units do not come on unless the load reaches the very maximum.

In addition, the ARB modified the rule to provide for two stages of control. The first is essentially 50 percent reduction required by 1982, and part of that would be demonstrating technology to reduce emissions by 90 percent by 1982.

The second stage is 90 percent control by 1990.

I might add that the demonstration of technology for 100-megowatt equivalent units was for the purpose of identifying precisely what reductions could be achieved, precisely what the problems would be, to identify if there were any problems that we weren't aware of, and primarily to get a good handle on how controls would operate prior to requiring widescale implementation of that technology.

Both the staff and the Air Resources Board do concur with the observation made by David Mobley of EPA and with the observation of the South Coast Air Quality Management District that selective catalytic reduction has been demonstrated to be feasible and commercially available for gas and oil fired power plants. Electric utilities in the South Coast Air Basin, and there are five of them, have now begun plans to comply with the first stage of emission reduction, using thermal DeNOx, selective catalytic reduction, and other combustion modification techniques.

Other stationary sources that are also being considered for further NOx control include, among other sources, boilers and heaters, including CO boilers, stationary engines, glass plants, residential heaters, to name a few.

To summarize, then, both state and federal NO_2 standards are exceeded by wide margins, and frequently, in the L.A. Basin, and without further controls of NOx we expect the situation to worsen. Both stringent mobile and stationary source controls will be needed to approach either the national or the state NO_2 standards.

The South Coast Air Quality Management District and the Air Resources Board have adopted, and continue to consider, further NOx controls to promote meeting the national and state standards.

Thank you.

MR. COERR: Vince Mirabella.

MR. VINCENT A. MIRABELLA: Unfortunately, I am in the position of having to go over a lot of the material that has already been presented, so please bear with me.

The Clean Air Act Amendments of 1977 represent a reaffirmation of Congress' mandate to accomplish the nation's air quality goals according to a legislated time schedule.

Of the many provisions contained within the Amendments, the key ones deal with non-attainment, PSD, review of ambient air quality standards and new source performance standards, regulation of hazardous substances, and establishment of a short-term NO_2 standard.

The impact of these provisions on the utility industry will be felt in various ways, as shown on the first slide.*

The impacts would be associated with requirements dealing with emission controls, such as best available control technology; RACT, which is reasonably available control technology; LAER, lowest achievable emission rate; and BART, which is defined as best available retrofit technology.

Other impacts will deal with siting constraints, such as proximity to PSD areas, and also facility design constraints, such as stack height limitations and fuel types. Also, there are dollar and energy costs resulting from the above impacts.

The processes by which these requirements will impact the industry are indeed complex, as the components of many of the requirements are interrelated and reinforcing. It is my intent today to briefly outline the nature of these processes as I see them. For this purpose I will make references to the present regulatory situation here in California since, as was previously mentioned, the State currently has a one-hour NO_2 standard.

Examination of the California situation provides a ready-made example of possible future directions of regulatory processes across the country, brought about by this short-term standard.

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* A copy of Mr. Mirabella's slide presentation follows the Panel Discussion.

As you previously heard, EPA is presently reviewing the annual NO_2 standard, and is preparing to promulgate a short-term NO_2 standard, and I have indicated in slide 2 what the ranges of possible values are. In terms of the short-term, the one-hour value that has been most frequently mentioned has been in the range of .1 to .50 ppm. Again, the State of California has a .25 ppm one-hour standard.

As far as the annual standard is concerned, the most probable value will be about 100 micrograms per cubic meter. I have also considered 80 micrograms per cubic meter as a "what if" kind of situation, to illustrate what the impacts could be should welfare effects dictate a lower annual secondary standard.

To set the problem in perspective for the discussion that follows, we will discuss first the indicated sources of NOx emissions. Now, as shown in slide 3, I have a nationwide inventory and the South Coast Air Basin inventory.

On a national basis, mobile sources comprise approximately 44 percent, power plants 29 percent, with other various sources the remainder. Compare this with the South Coast Air Basin. I guess my numbers differ a little bit from what Frank's numbers are, but mobile sources are roughly about two thirds, with power plants somewhere around nine or ten percent, and other stationary sources the balance.

With this in mind, it is instructive to next examine the current attainment status of each air quality control region across the country as shown in slide 4. Now, what this map depicts are all the air quality control regions, and the annual average NO_2 compliance status as of 1975-1976 data.

Of the initial non-attainment designations by EPA, such areas were located in California and Chicago. Based upon the 1975-76 data, eight air quality control regions may exceed the annual 100-microgram-per-cubic-meter number, and 25 may exceed the 80-microgram-per-cubic-meter number. As you can also see, there are a number AQCR's which do not have sufficient information from which a determination can be made.

Shown in slide 5 is the attainment status of two one-hour NO_2 standards, the .25 and the .5 ppm levels. Seventy-seven AQCR's I have been able to find out had continuous, adequate data from which an assessment can be made of compliance.

For the .25 ppm case, 28 of these AQCR's, or 36 percent, have levels in excess of .25 ppm. For the half-a-part-per-million case, nine AQCR's, or 12 percent of the total, have levels in excess of .5 ppm.

Now, not shown here is an assessment for the .1 ppm case, and that shows that 57, or 74 percent of the AQCR's had levels in excess of .1 ppm for one or more hours.

The majority of the non-attainment areas, for the most part, are located in the metropolitan urban areas. I would also add from this slide that there are a significant number of AQCR's which do not have adequate continuous monitoring data from which the compliance can be determined, so there is a possibility of additional AQCR's which could be non-attainment.

Now, for those areas identified in these slides as non-attainment, existing megawatt capacity located in such areas is shown here in slide 6. The limiting standard apparently is the .25 ppm number, and that shows that over 100,000 megawatts of existing generating capacity are located in potential non-attainment areas. This comprises approximately 30 percent of the total fossil-fuel capacity of the country.

I might also add at this point that a review of planned generating capacity during the period of 1978 to 1989, as shown in slide 7, indicates that up to 38 percent, or 64,000 megawatts of a total of 170,000, could be located in the potential non-attainment areas.

Now, the significance of this review of non-attainment areas lies in the specification of emission control requirements for new and existing stationary sources located in such areas.

This is kind of a busy slide (slide 8), but the degree of control will be dependent upon whether the source is new or existing. In terms of existing sources, the requirement is for reasonably available control technology, which is defined as that control required of existing sources to roll back to national levels, national ambient air quality standards.

For new sources located in non-attainment areas, LAER, lowest achievable emission rate, is required. This is the lowest achievable emission rate nationally, either in SIP or in practice, and the significance of this point I will clean up a little later.

BART stands for best available retrofit technology, and is required for existing sources less than 15 years old, primarily for visibility protection.

BART, although it is not required for sources in non-attaining areas, can ultimately be affected by LAER, and vice versa. These are the so-called reinforcing parts of the Clean Air Act Amendments.

Slide 9 depicted here describes the NOx emission control technology as applied to utility boilers and they consist primarily, at this time, of combustion modifications, such things as low excess air, flue gas recirculation, water or steam injection, and so forth. They are widely considered reasonably available, and have been demonstrated, at least in the Edison system, to produce emission control reductions on the order of 10 to 50-plus percent.

The costs as shown here are costs for the Edison system only, and are based on somewhere between $100 and $1,000 a ton, depending on such things as individual unit size, capacity factors, what the starting level of the reduction was.

The second class of control technology deals with flue gas treatment, and two are identified here, ammonia injection and selective catalytic reduction. I might add that the ammonia injection is identified in the California SIP as a RACT measure.

I show here that cost can vary anywhere between $2,000 and $4,000 per ton removed for the injection system, and for the catalytic system it is anywhere from $4,500 to $9,000 plus, per ton.

The significance of this is that by defining RACT with ammonia injection, that pretty much sets the stage for all other non-attainment areas to classify this as reasonably available control technology along with the selective catalytic treatment.

As to the nature of these RACT measures, I would like to very briefly touch on their basis. The next slide (slide 10) provides provisions of so-called Rule 475.1, which Frank alluded to earlier. This was adopted, final adoption, in January, 1979, and it is a two-stage implementation plan, whereby 50 percent NOx control is required on a systemwide average of all the units in the South Coast area. These are retrofit plans, and as you can see, require a 50 percent systemwide average, which means certain units will have to operate at higher control, and others lower. It also applies throughout the entire load range as well.

Compliance demonstration is scheduled for December 31, 1982, with construction probably to begin sometime this year. It also requires the installation of a demonstration unit, capable of demonstrating 90 percent control also by 1982.

Now, providing the demonstration project proves out, then all of the existing capacity of the South Coast Air Basin would have to be retrofitted, and this control efficiency of 90 percent in effect represents selective catalytic reduction.

Slide 11 provides a comparison of NOx emission standards for utility purposes, indicating the present new source performance standards for coal and oil, the proposed new source performance standards, and what standards there are presently in the South Coast Air Basin.

As you can see, the existing units must comply with .3 lbs. per million BTU. After 1981 they have to comply with .15, and after 1989, .03 lbs. per million BTU is used.

Now, suffice it to say our company has objected strenuously to the promulgation of such emission standards, because of the lack of a technical basis. No full-scale utility boiler in the range of 200 to 750 megawatts has ever been retrofitted with the ammonia injection process that achieved 50 percent average NOx removal efficiency, and no retrofitted oil- or coal-fired utility boiler has ever achieved 90 percent removal efficiency with the catalytic process.

Both processes are within the realm of theoretical or experimental technology which is neither available now nor in practice anywhere in the country or, for the most part, in the world.

Furthermore, the compatability of the two systems, which must be installed in tandem in order to demonstrate the final control, has not even been experimentally verified.

Now, as to cost for this Rule 475 implementation, we estimate that, in 1978 dollars, the annualized cost for the ammonia injection system for our 6,000-megawatt in-basin system will be $92,000,000 to remove 50 tons per day, on that order. That represents capital of $160,000,000, outage cost of $25,000,000 in order to install the equipment, and annual operation and maintenance costs of $49,000,000.

For the catalytic retrofit system, we estimate the cost of capital at $1.2 billion, outage cost of $100,000,000, and annual operation and maintenance costs of $275,000,000. And that is in 1978 dollars. Of course, the cost will be considerably higher in the future.

Now, in view of these considerations, it is of interest at this point to examine relative effectiveness of reducing NOx emissions from various sources in achieving a national ambient air quality standard for NO_2.

To accomplish this task, a methodology was developed to estimate concentration and emission factors for various source categories. This next slide (slide 12) shows the basis for these concentrations of emission factors.

The methodology makes use of the fact that each emission source category has a unique sulfur dioxide-carbon monoxide emission ratio. With this method, SO_2 can be used as a tracer for stationary-source impacts on NO_2, and CO as a tracer for mobile-source impacts on NO_2.

As you can see, mobile sources have their ratio somewhere around .01, whereas stationary sources are in the range of one to 50.

Now, provided NO_2, CO, and SO_2 can be monitored concurrently, and also provided the relative strengths of the sources affecting a monitoring station are known, the relative abundance of CO and SO_2 should provide a clue as to the types of sources affecting that station.

By the use of this concept, the contributions of various NOx emission sources to the ambient NO_2 level at downtown Los Angeles, which typically has the highest NO_2 short-term levels, are indicated in slide 13. This is considering all days during the period 1974 to 1976.

As you can see, power plants contributed only three percent to the NO_2 air quality at downtown Los Angeles, whereas mobile sources contributed 57 percent, and the balance by other area sources.

A similar analysis was completed for other locations in the South Coast Air Basin. The results were essentially the same. Mobile sources continued to be the dominant source of the NO_2 problem in the South Coast Air Basin.

Now, taking these emission source factors, we computed the contribution of various sources to the NO_2 annual average and the average one-hour NO_2 on days of highest NO_2, as shown in slide 14. Taking the annual, for instance, Los Angeles showed a 141-microgram-per-cubic-meter highest annual average between the years of 1974 and '77.

The NO_2 source contributions indicate that 80 micrograms were being contributed by mobile sources, four micrograms by power plants, and 57 micrograms by other area sources. We have also looked at figures with respect to both mobile and stationary sources in other areas of the SCAB, with the results you see there.

The same kind of thing shows up when you look at source contribution for NO_2 in other areas of the country. Mobile sources clearly dominate the NO_2 background.

What this boils down to is that maximum controls on power plants will not significantly influence the NO_2 levels. Yet, costly controls on power plants are mandated requirements.

Finally, this next figure, slide 15, deals with the effects of NOx controls in urban areas on attainment of the ozone standard. Now, this next slide provides the South Coast Air Quality Management Plan analysis of the actual hydrocarbons and NOx controls necessary to meet the federal ozone standard. It may be kind of difficult to see, but the bottom line of this is that, if you do not control NOx emissions from their levels of 1974, just control hydrocarbons according to their current control strategies, you would achieve the standards with much greater ease than you would with a combination of hydrocarbon and NOx controls.

Now, this is a rather simplified analysis, this ozone isopleth technique. We have also conducted extensive model studies which Frank alluded to earlier, which indicate to us that there will be substantial increases in ozone levels down wind of the power plants when such power plants are controlled of NOx emissions. The effects of NOx control on ozone must be taken into account when developing integrated NO_2 and ozone control strategies.

My last area of discussion will focus on PSD requirements. As indicated in the Clean Air Act Amendments, these areas meeting air quality standards are designated as attainment and subject to PSD requirements.

It is impossible to presently give PSD increments for NO_2. In fact, formulation of PSD is not firm by any means, although for the sake of discussion I have looked at it, following the House of Representatives technique for estimating PSD increments for the various standards.

These levels are exceptionally low, as you might be able to see from slide 16. Class 1 was defined as two percent of the standard, Class 2 as 25 percent, and Class 3 as 50 percent. In these areas, BACT will be required, which may possibly require controls up to 50 to 90 percent.

Looking at proposed power plants in the attainemnt areas, we have been able to locate 51 new plants in identifiable attainment areas for both the annual and one-hour standards.

Projecting NOx emissions to 1989 in each attainment area where new plants were located, it was determined that 14 of the designated 51 plants, or nearly 50 percent of the megawatt capacity, may require NOx control in excess of the proposed new source performance standard in order to meet Class 2 increments.

The next two slides (slides 17 and 18) show the location of power plants, planned power plants, in relation to PSD Class 1 areas. The red dots indicate the location of the power plants. The yellow indicates discretionary Class 1 areas, which are presently Class 2, but could be Class 1 in the future. And the green areas are shown as mandatory Class 1 areas at the time of the Clean Air Act Amendments.

Of the total number of planned plants, 188 have location information. Of these, 27 plants, or 26,000 megawatts, are located within 50 kilometers of a Class 1 area or potential Class 1 area, and therefore could be influenced by the PSD increments.

In conclusion, I would like to show the following figures (slide 19). The promulgation of the proposed NO_2 standards, on an annual and short-term basis, could have a substantial impact on the utility industry, because of the nature of the control requirements for new and existing power plants.

Over 100,000 megawatts of existing power plants, or 30 percent of existing fossil fuel power capacity, are located in 29 potential non-attainment areas. Reasonably available control technology is required of existing sources located in non-attainment areas.

Using the California SIP as an example, RACT may require up to 50 to 90 percent reduction of existing utility emissions. Retrofit of this control can be extremely expensive, amounting to billions of dollars.

Moreover, in some non-attainment areas, this control is unlikely to substantially affect ambient NO_2 levels.

The California RACT measures will ultimately affect the basis for LAER and BART requirements. Up to 38 percent of the planned capacity will be located in potential non-attainment areas and subject to LAER requirements.

Control of NOx emissions and meeting the NO_2 standards must be judged in light of potential urban ozone levels. Now, unless emission offsets are required in PSD areas, about one-half of all the plants could require emission controls more stringent than the proposed NSPS.

Finally, NOx may replace SO_2 as a pollutant controlling facility and site suitability, and that is the bottom line.

Thank you.

MR. COERR: Thank you, Vince.

I would like to take some questions from the floor, but before that, we will see if the panel members have any clarifications they want to make before we get into that.

MR. DiGENOVA: I have one point I would like to clarify.

I tried to describe a little bit in my presentation the 475.1 systemwide concept, and I think it would be helpful if I went back for a moment and gave you a little bit of the history, just to clarify one point.

Last summer, when the Air Resources Board first published a modification to the South Coast Air Quality Management District rule, we considered a one-stage rule that required 90 percent control.

In response to substantial testimony that we got from control equipment manufacturers and from the utilities themselves, that rule was modified to a two-stage rule, but again, the concept of systemwide control was retained.

The effect of systemwide control was that base-loaded units, for example larger units with longer remaining lifetime, can utilize a greater degree of control, and older units that have a shorter remaining lifetime, percentage-wise, that is, can utilize a lesser degree of control.

The amount of control required is equivalent, for stage one, to all existing units getting 50 percent. I think there were some comments made by Vince, that all units will be required to have 90 percent control for stage two, and that is not correct.

(A question and answer period followed, which was not reported.)

PANEL DISCUSSION
SLIDE PRESENTATION

by

Vincent A. Mirabella
Southern California Edison

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SLIDE 1

KEY IMPACTS ON UTILITY INDUSTRY DUE TO THE CAAAs OF 1977

1. Emission Control Requirements (e.g., BACT, RACT, LAER, BART)
2. Siting Constraints (e.g., proximity to PSD areas)
3. Facility Design Requirements (e.g., stack height, fuel type)
4. Dollar/Energy Costs Resulting From (1) to (3) above

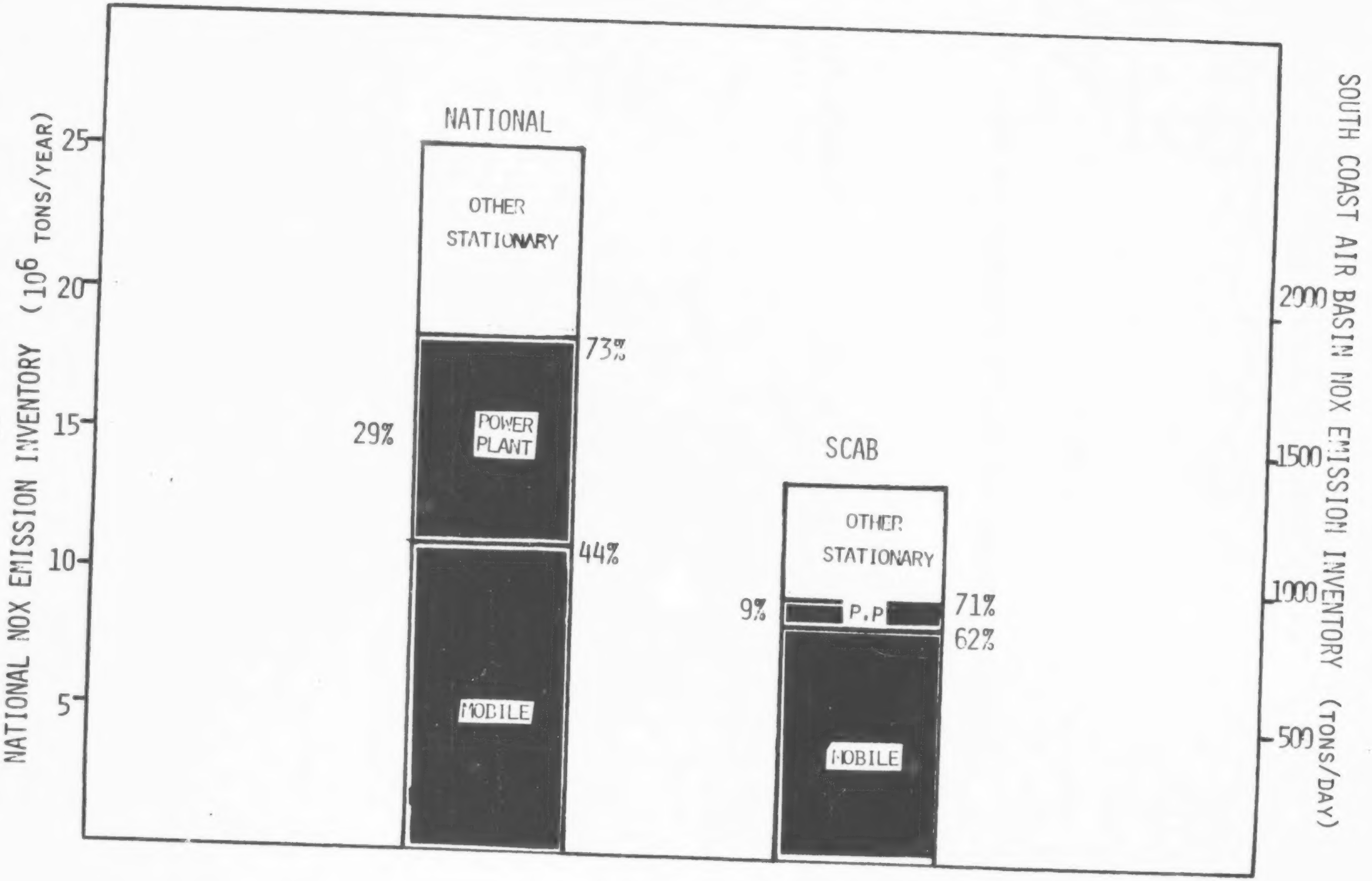
SLIDE 2

POTENTIAL AMBIENT AIR QUALITY STANDARDS FOR NO_2

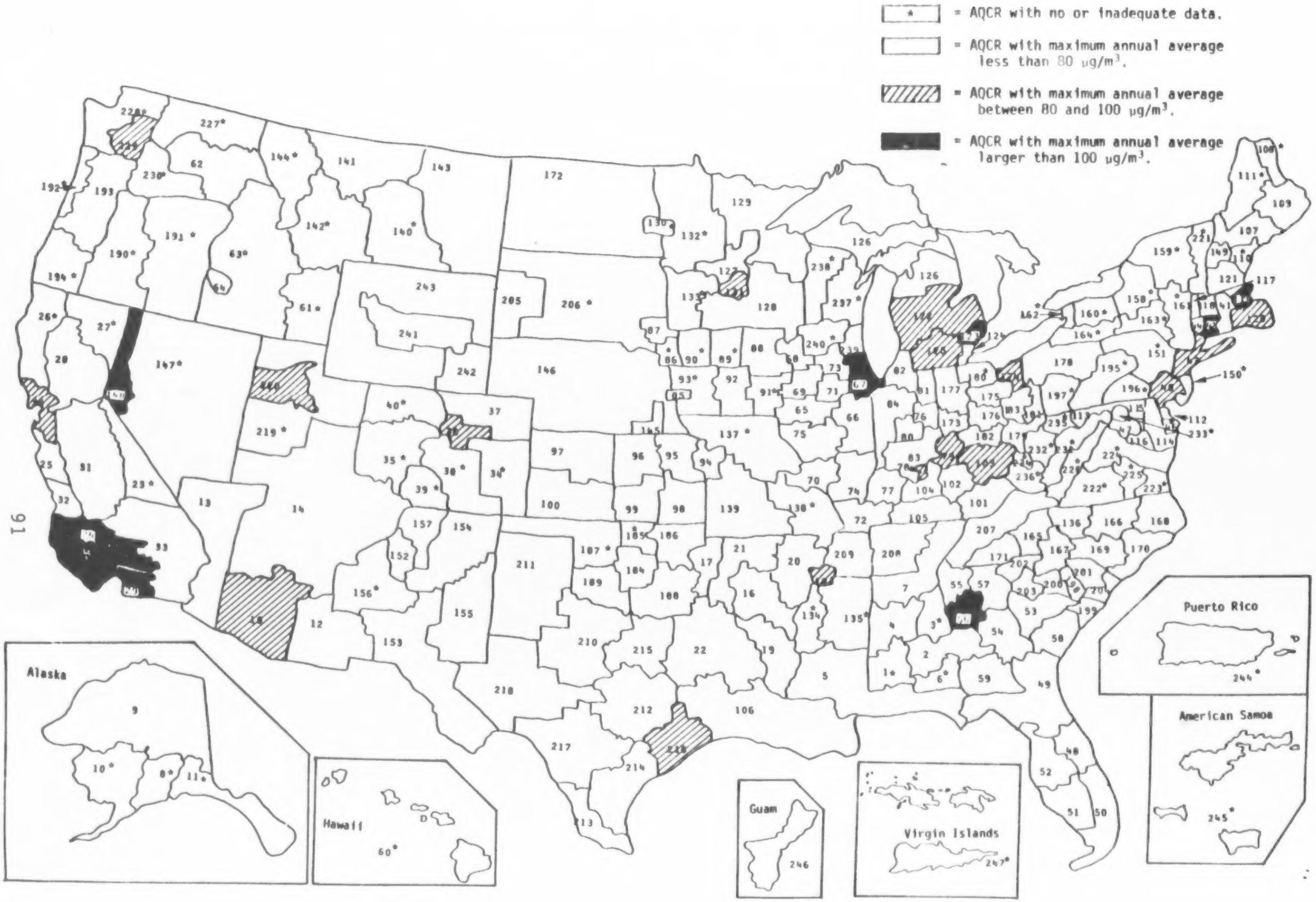
AVERAGING PERIOD	RANGE OF VALUES UG/M^3 (PPM)	PROBABLE VALUE UG/M^3 (PPM)
ANNUAL	80 - 100	100*
	(0.04) - (0.05)	(0.05)
1-HOUR	188 - 940	470**
	(0.1) - (0.50)	(0.25)

* PRESENT ANNUAL PRIMARY NO_2 STANDARD

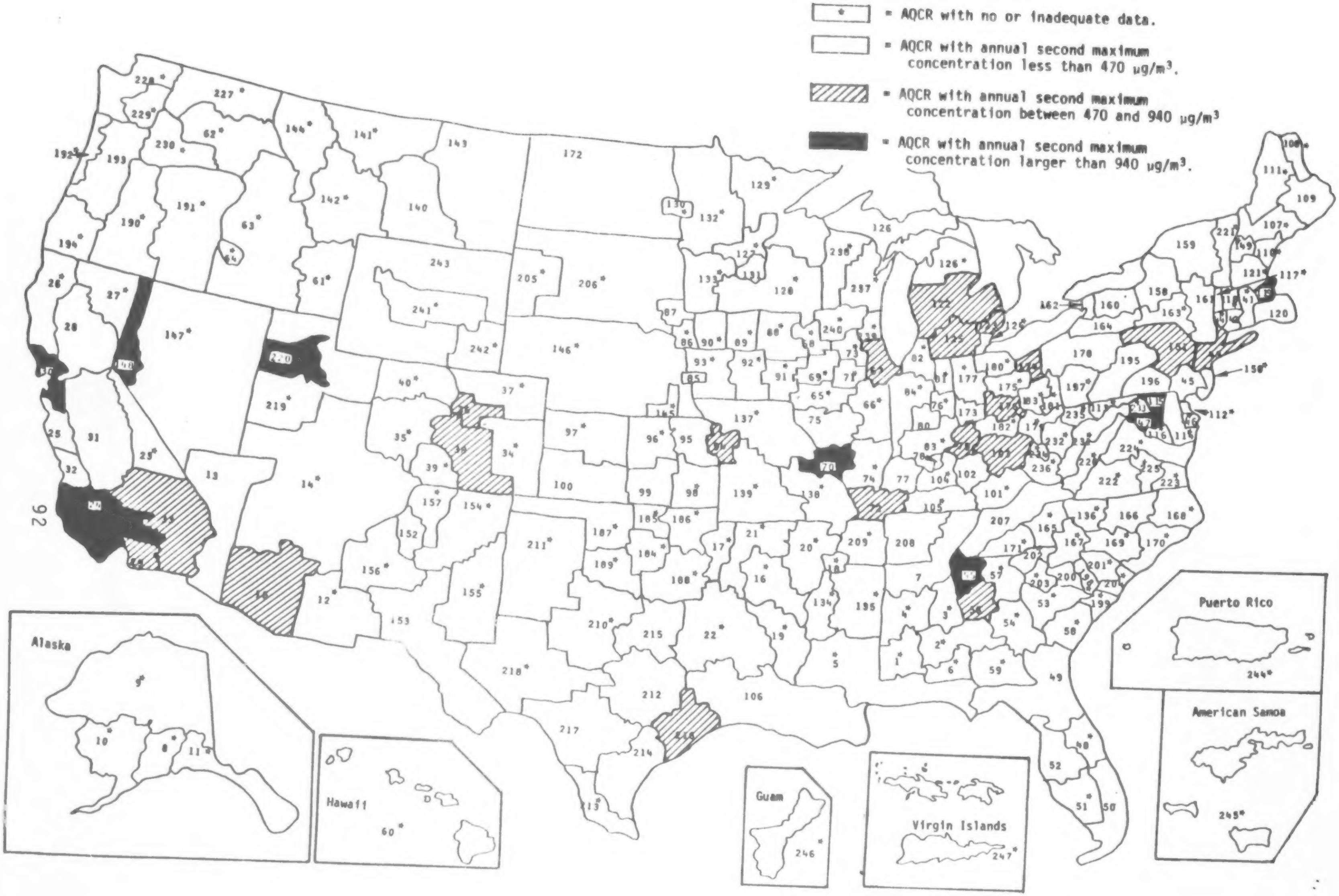
** CURRENT CALIFORNIA 1-HOUR NO_2 STANDARD



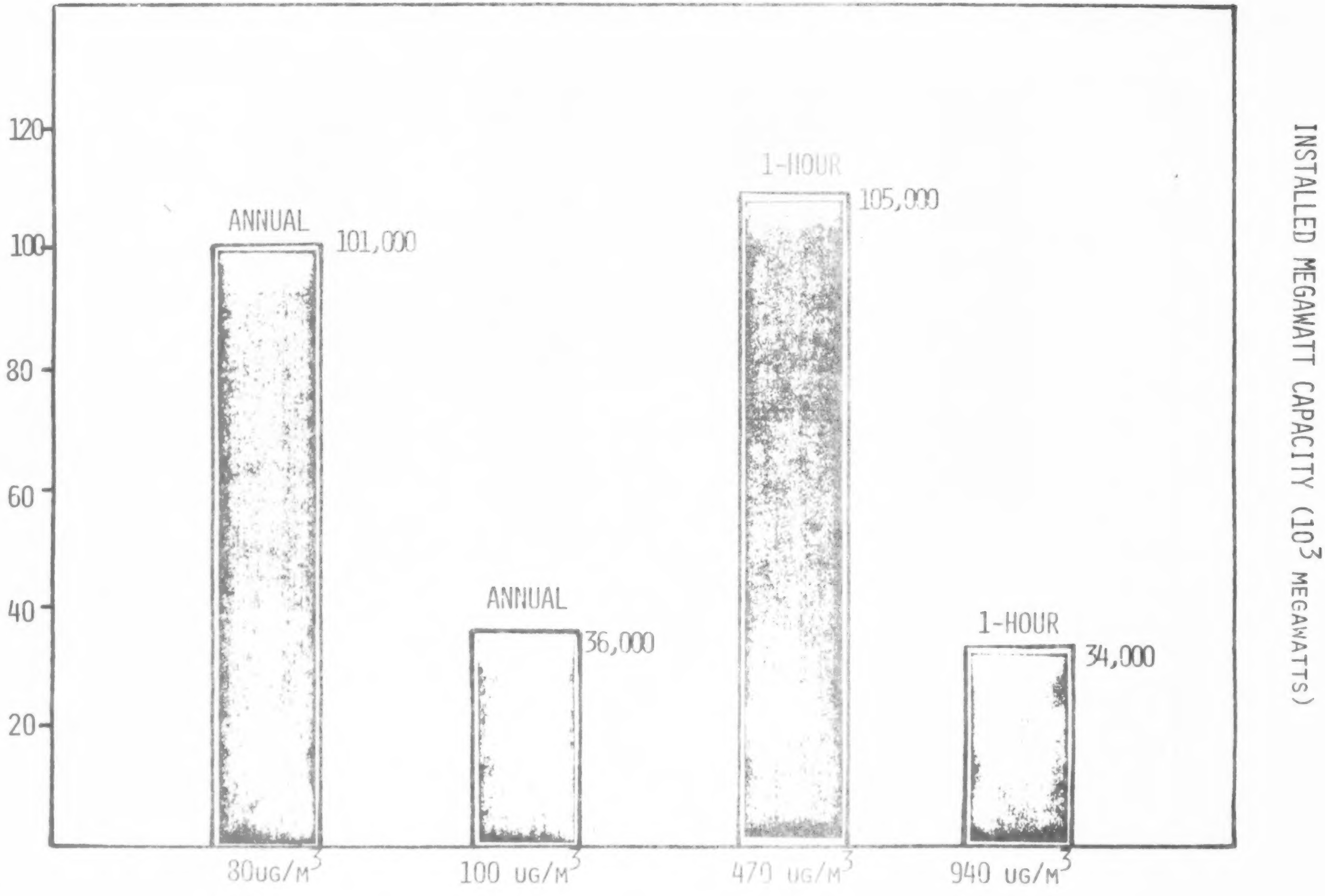
SLIDE 3 NATIONAL AND SOUTH COAST AIR BASIN NOX EMISSION INVENTORIES 1976


= AQCR with no or inadequate data.
= AQCR with maximum annual average less than 80 μg/m³.
= AQCR with maximum annual average between 80 and 100 μg/m³.
= AQCR with maximum annual average larger than 100 μg/m³.
Alaska
Hawaii
Guam
Virgin Islands
Puerto Rico
American Samoa

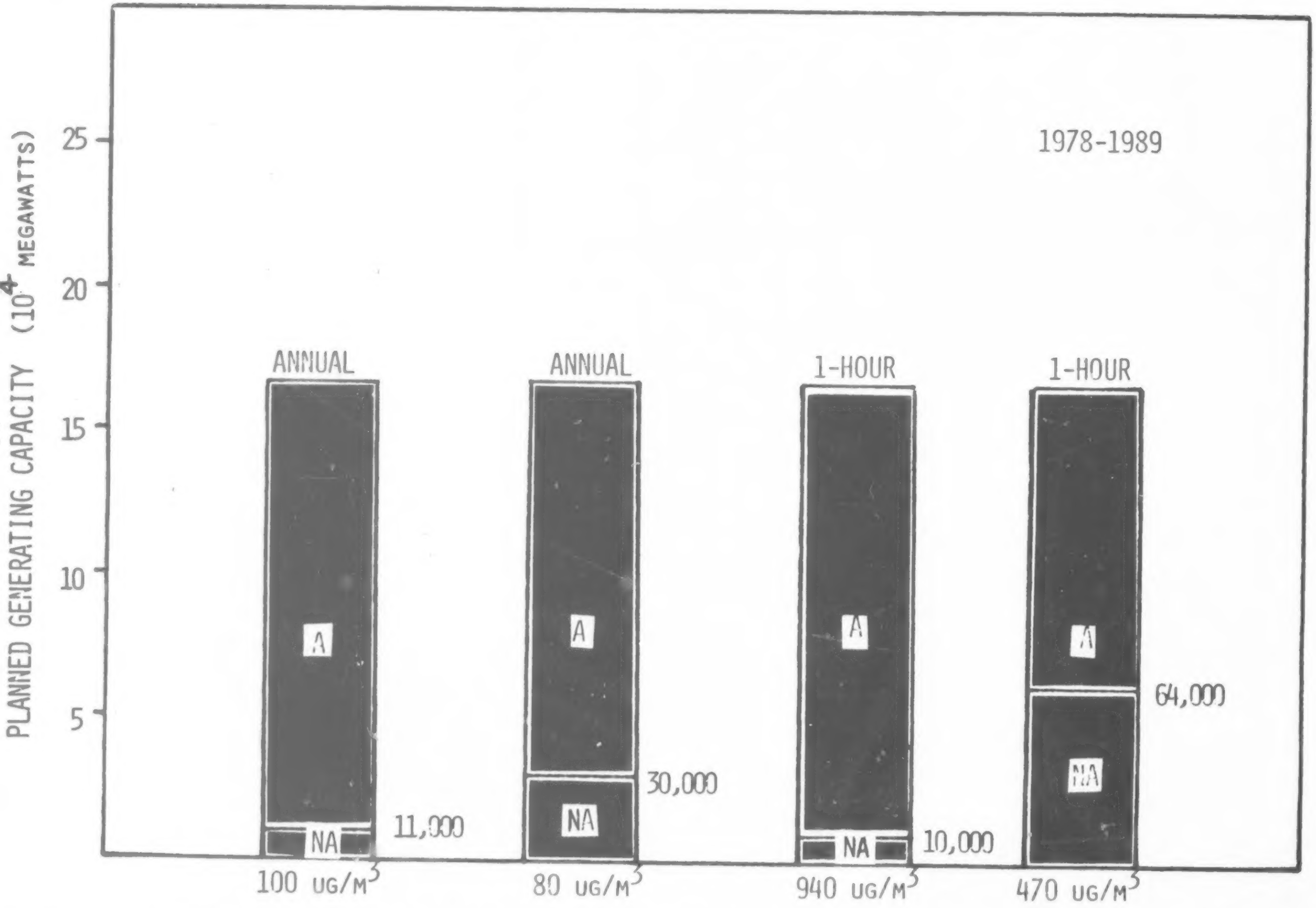
SLIDE 4. STATUS OF COMPLIANCE WITH ANNUAL NO_2 STANDARDS


* = AQCR with no or inadequate data.
= AQCR with annual second maximum concentration less than 470 μg/m³.
▨ = AQCR with annual second maximum concentration between 470 and 940 μg/m³
■ = AQCR with annual second maximum concentration larger than 940 μg/m³.
Alaska
Hawaii
Guam
Virgin Islands
Puerto Rico
American Samoa

SLIDE 5. STATUS OF COMPLIANCE WITH 1-HOUR NO_2 STANDARDS



SLIDE 6 INSTALLED MEGAWATT CAPACITY LOCATED IN POTENTIAL NONATTAINMENT AREAS FOR NO_2 (1975-76)



SLIDE 7 PLANNED FOSSIL-FUELED POWER PLANTS LOCATED IN ATTAINMENT AND NONATTAINMENT AREAS NO_2 (1975-76)

SLIDE 8

EMISSION CONTROL REQUIREMENTS FOR NEW OR EXISTING EMISSION SOURCES LOCATED IN NONATTAINMENT AREAS

REQUIREMENT*	NEW OR MODIFIED SOURCE	EXISTING SOURCE
RACT (LOCAL)		X
LAER (NATIONAL)	X	
BART (LOCAL/FEDERAL)		X
BACT (LOCAL)		

* RACT - REASONABLY AVAILABLE CONTROL TECHNOLOGY: REQUIRED OF EXISTING SOURCES AND IS DEFINED AS THAT CONTROL REQUIRED OF EXISTING SOURCES TO ROLLBACK AMBIENT LEVELS TO THE NAAQS BY DECEMBER 31, 1982.

* LAER - LOWEST ACHIEVABLE EMISSION RATE: LOWEST ACHIEVABLE NATIONALLY EITHER IN AN SIP OR IN PRACTICE.

* BART - BEST AVAILABLE RETROFIT TECHNOLOGY: REQUIRED OF EXISTING SOURCES LESS THAN 15 YEARS OLD; FOR VISIBILITY PROTECTION.

* BACT - BEST AVAILABLE CONTROL TECHNOLOGY: APPLIES TO ALL NEW OR MODIFIED SOURCESLOCATED IN PSD AREAS; HOWEVER, BACT CAN UTIMATELY AFFECT LAER AND VICE VERSA.

SLIDE 9

NOx EMISSION CONTROL TECHNOLOGY AS APPLIED TO UTILITY BOILERS

COMBUSTION MODIFICATIONS	DEGREE OF CONTROL (%)	CONTROL COST*** ($/TON-NOx)
Low excess air, flue gas Recirculation, water or steam injection, reduced air preheat, and off-stoichiometric combustion	10-50*	100-1000
FLUE GAS TREATMENT**		
Ammonia Injection	40-50	2000-4000
Selective Catalytic Reduction	90	4500-9000+

* Higher control reflects combinations of control techniques

** Ract measures in the California SIP: measures provide basis for setting Bact, Laer, Ract, and Bart for NOx.

*** Control costs will vary widely for individual units depending on unit size and capacity factors

SLIDE 10

PROVISIONS OF THE SCAQMD RULE 475.1 (REDUCTION OF POWER PLANT NOx EMISSIONS)

FINAL ADOPTION: JANUARY 22, 1979

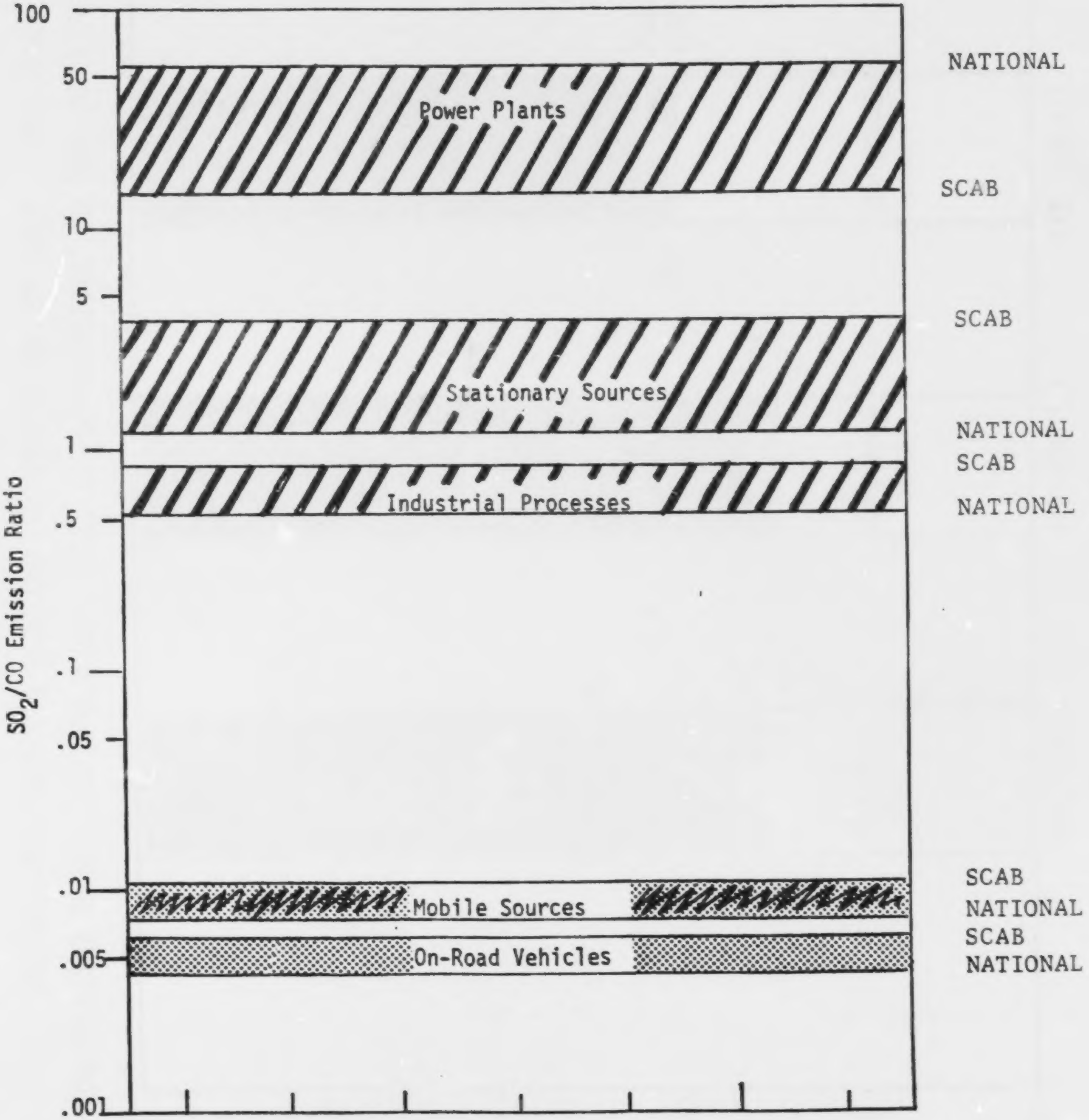
IMPLEMENTATION STAGE	PROVISIONS	MILESTONE DATE
I	Installation of 50% NOx control, system-wide average on all Units in SCAB	
	A) Control plan	A) April 1, 1979
	B) Construction contracts	B) July 1, 1979
	C) Compliance demonstration	C) December 31, 1982
	Installation of a demonstration unit, greater than 100MW, capable of demonstrating 90% NOx control	
	A) Compliance demonstration	A) January 1, 1982
II	Installation of control equipment to effect 90% of NOx reduction subject to review by regulatory agencies	
	A) Control plan	A) July 1, 1983
	B) Compliance demonstration	B) January 1, 1990

SLIDE 11

NO_x EMISSION STANDARDS FOR UTILITY BOILERS

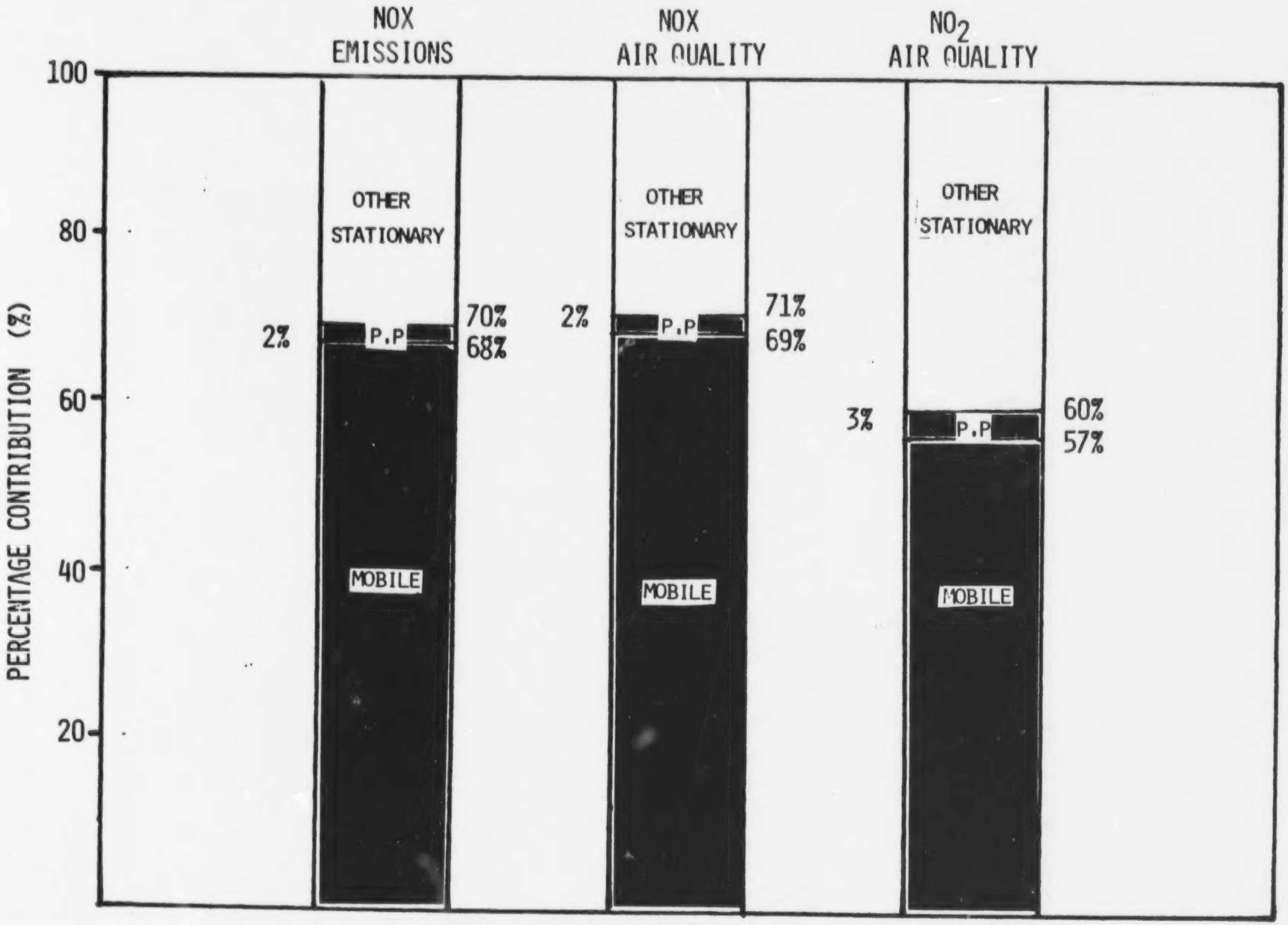
(LB/10^6 BTU)

	COAL	OIL
PRESENT NSPS	0.7	0.3
PROPOSED NSPS	0.5, 0.6	0.3
SCAB		
EXISTING UNITS	0.3	0.3
NEW AND EXISTING UNITS (AFTER 1981)	0.15	0.15
NEW AND EXISTING UNITS (AFTER 1989)	0.03	0.03



Ranges of Typical (SO_2/CO) Emission Ratios in Various Source Categories.

SLIDE 12



SLIDE 13 CONTRIBUTION OF NOX EMISSION SOURCE TYPES TO NOX EMISSIONS, AMBIENT NOX LEVELS, AND AMBIENT NO2 LEVELS AT DOWNTOWN LOS ANGELES ON ALL DAYS (1974-1976)

SLIDE 14

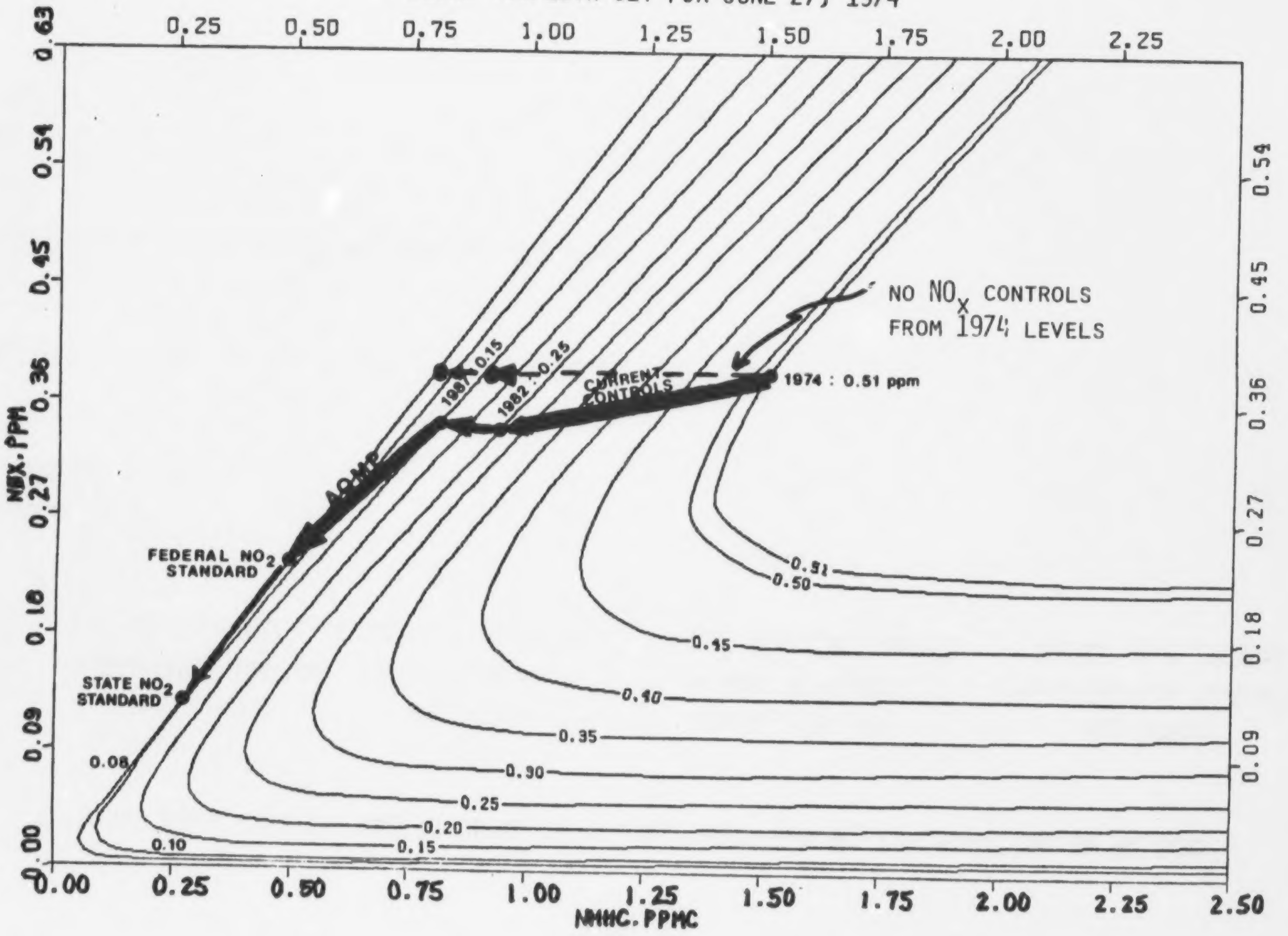
EMISSION SOURCE CONTRIBUTIONS TO ANNUAL AVERAGE AND SHORT-TERM NO_2 CONCENTRATIONS IN THE SCAB

SITE	HIGHEST ANNUAL AVERAGE CONCENTRATION 1974-1977 (UG/M^3)	NO_2 SOURCE CONTRIBUTION (UG/M^3)			AVERAGE 1-HR. NO_2 ON DAYS OF HIGHEST NO_2* 1974-1977 (UG/M^3)	NO_2 SOURCE CONTRIBUTION (UG/M^3)		
		MOBILE	P.P	OTHER		MOBILE	P.P	OTHER
DOWNTOWN LOS ANGELES	141	80	4	57	188	126	7	55
WHITTIER	135	100	15	20	225	176	18	31

* DAYS WHEN A 1-HOUR AVERAGE NO_2 EXCEEDED 470 UG/M^3

SLIDE 15

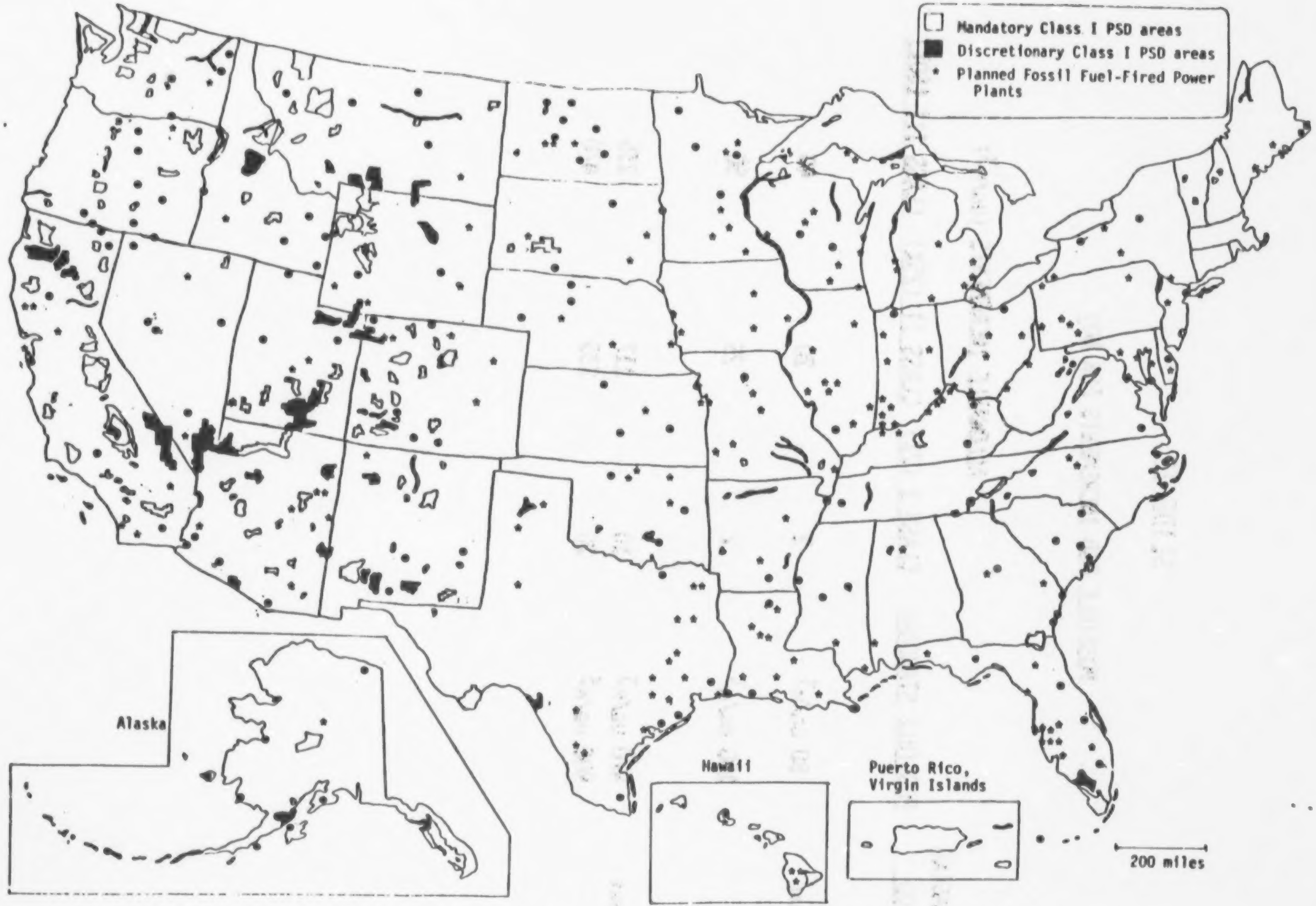
OZONE ISOPLETH SET FOR JUNE 27, 1974



SLIDE 1C

POSSIBLE PSD INCREMENTS FOR NO_2

AVERAGING PERIOD	POSSIBLE STANDARD	ALLOWABLE INCREMENTS (UG/M^3) CLASS I (2%)	CLASS II (25%)	CLASS III (50%)
ANNUAL	80 UG/M^3	2	20	40
	100 UG/M^3	2	25	50
1-HOUR	470 UG/M^3	10	117	235
	940 UG/M^3	20	235	470


Mandatory Class I PSD areas
Discretionary Class I PSD areas
Planned Fossil Fuel-Fired Power Plants
Alaska
Hawaii
Puerto Rico, Virgin Islands
200 miles

SLIDE 17 RELATIONSHIP OF SCHEDULED FOSSIL FUEL POWER PLANTS TO MANDATORY AND DISCRETIONARY CLASS I PSD AREAS

/

SLIDE 13

DISTANCES BETWEEN SCHEDULED POWER PLANTS AND PSD CLASS I AREAS

DISTANCE (KM)	MANDATORY AND DISCRETIONARY CLASS I AREAS CAPACITY MW	 CUM %
10	6,000	5.8
30	15,500	15.0
50	26,300	25.2
70	37.300	36.1

SOURCE: FLOW RESOURCES CORP. 1979

SLIDE 19

CONCLUSIONS

- THE PROMULGATION OF A SHORT-TERM NO_2 STANDARD AND THE POSSIBLE REVISION OF THE ANNUAL NO_2 STANDARD COULD HAVE SUBSTANTIAL IMPACTS ON THE UTILITY INDUSTRY IN TERMS OF EMISSION CONTROL REQUIREMENTS FOR NEW AND EXISTING POWER PLANTS.
- OVER 100,000 MW OF EXISTING POWER PLANTS OR 30% OF EXISTING FOSSIL CAPACITY ARE LOCATED IN 29 POTENTIAL NONATTAINMENT AQCRS.
- REASONABLY AVAILABLE CONTROL TECHNOLOGY (RACT) IS REQUIRED OF EXISTING SOURCES LOCATED IN NONATTAINMENT AREAS; USING THE CALIFORNIA SIP AS AN EXAMPLE, RACT MAY REQUIRE UP TO 50-90% REDUCTION OF EXISTING UTILITY EMISSIONS. RETROFIT OF SUCH CONTROLS WILL BE EXTREMELY EXPENSIVE, AMOUNTING TO POTENTIALLY BILLIONS OF DOLLARS. MOREOVER, IN SOME NONATTAINMENT AREAS SUCH POWER PLANT CONTROLS ARE UNLIKELY TO SUBSTANTIALLY AFFECT AMBIENT NO_2 LEVELS IN ACHIEVING THE NAAQSS.
- THE CALIFORNIA RACT MEASURES WILL ULTIMATELY SET THE BASIS FOR LAER AND BACT REQUIREMENTS.
- UP TO 38% OF PLANNED CAPACITY WILL BE LOCATED IN POTENTIAL NONATTAINMENT AREAS AND SUBJECT TO LAER.
- CONTROL OF NOX EMISSIONS IN MEETING NO_2 STANDARDS MUST BE JUDGED IN LIGHT OF POTENTIAL IMPACTS ON URBAN OZONE LEVELS.
- UNLESS EMISSION OFFSETS CAN BE ACQUIRED IN PDS AREAS, ABOUT ONE-HALF OF ALL NEW FOSSIL-FUEL POWER PLANTS COULD REQUIRE EMISSIONS CONTROLS MORE STRINGENT THAN THE RECENT NSPS AS PROPOSED.
- ABOUT 25% OF ALL NEW POWER PLANT CAPACITY WILL BE LOCATED CLOSE ENOUGH TO POSSIBLE PSD CLASS I AREAS TO BE POTENTIALLY IMPACTED BY RELATED EMISSION REQUIREMENTS.
- NOX MAY REPLACE SO_2 AS THE POLLUTANT CONTROLLING FACILITY AND SITE SUITABILITY.

TOWARDS A RESEARCH PLAN TO STUDY EMISSIONS FROM SMALL INTERNAL COMBUSTION ENGINES

By:
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Abstract

This paper examines some of the requirements for investigating environmental status of small internal combustion engines. These engines range in size form 1½ hp to 15 hp and power a variety of equipment by home owners and industrial members.

With the general growing concern in EPA of identifying sources of potentially carcinogenic emissions, there exists a possibility that these small internal combustion engines are a problem source. Research to characterize emissions from the source has largely been limited to critical pollutants, even though the small internal combustion is an imcomplete combustion; therefore, some carcinogens and other hazardous compounds are probable.

The basic requirements addressed for an integrated research design include:

a) analytical equipment
b) experimental systems design
c) statistical experimental design.

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I. INTRODUCTION

BACKGROUND:

Over the past decade, population and energy consumption by way of the internal combustion engine have increased dramatically. Concomitant with these increases has been a dramatic increase in the nation's air pollution problem. An elevated awareness of the hazardous aspects of emissions from these engines has been developed. Most of the research and the ensuing legislation has been aimed at the gasoline powered automobile, and rightfully so. Recently, diesel engines have been given greater attention because of their ever increasing numbers. However, relatively little attention has been focused on the small internal combustion engines in spite of their wide spread usage. Here "small" is defined as 15 horsepower or less and includes engines used to power equipment such as garden tractors, motor tillers, lawn mowers, chain saws and other recreational, industrial and agricultural equipment. General growing concern to identify sources of sources of potentially carcinogenic emissions, has caused the EPA to explore the possibility internal combustion engines are a problem source. These engines are incomplete combustors, therefore there is a high probability that carcinogens and hazardous compounds are emitted.

Among the more prominent emissions

- -hydrocarbons
- -carbon monoxide
- -oxides of nitrogen
- -particulates.

Some detrimental health effects of these compounds are well known. Unburned hydrocarbons have an objectionable odor, contribute to photochemical smog and are possibly carcinogenic. Hydrocarbons may also show up as particulate matter. Studies have shown that high molecular weight hydrocarbons have been carcinogenic in animals.

The toxicity of carbon monoxide has been well documented. It occurs because blood hemoglobin has a higher affinity for carbon monoxide than for oxygen. After approximately one hour of exposure to carbon monoxide at 600 ppm, humans go into coma. Death usually occurs after one hour of exposure at 800 ppm. There is epidemiological data suggesting increased incidence of mortality from myocardial infarction after continual average weekly exposure to carbon monoxide concentrations of 8 to 14 ppm.

Oxides of nitrogen have a tendency to combine with lung moisture to form dilute nitric acid. This may cause respiratory problems over extended periods of time. Oxides of nitrogen are also known to settle on blood hemoglobin.

Particulates come from lead additives, hydrocarbons and sulfur dioxide. For the most part, their effects on health are related to injuries to the surface of the respiratory system. However, particulate materials in the respiratory tract may produce internal injury. Eye-injury is another possible detrimental effect.

Purpose:

The purpose of designing a comprehensive research plan is to allow emissions form these small internal combustion engines to be characterized. This characterization would account for the interactive impact of several factors on determining the acceptability of projected ambient concentrations of various emission compounds. As was stated earlier, the primary compounds are: hydrocarbons, carbon monoxide, oxides of nitrogen, and particulates. The central factors which may cause significant variations in emissions are:

-age of engine
-carburetor setting
-revolutions per minute
-mode (or load).

The design of a comprehensive research plan involves the completion of four tasks:

1. An information search and assessment
2. An analytical equipment design
3. An experimental system design
4. A statistical experimental design.

I shall briefly touch upon each of these tasks.

TASK 1: Information Search and Assessment

The first objective of this task is to provide information needed to complete an environmental assessment and impact evaluation. This requires mass emissions data based on an assumed operating cycle. A knowledge of the current distribution of these engines by size and other characteristics is necessary for extending available data to the entire population of these engines. An estimation of national impact will depend on:

-emission rates
-engine population, and
-average annual usage.

Each of these variables presents its own special measurement problem. Average annual usage presents a bias problem since the use of this variable masks the effects of its inherent variability. This problem is relatively dramatic in exposure computation since the individual who is periodically exposed to emissions from his three horsepower lawnmower is given the same weight as the individual who operates a chain saw, which has an identical engine, on a daily basis for extended periods of time.

In spite of these obvious kinds of problems, developing a literary information base will yield the best proxies.

This part of the currently ongoing project has been completed. The information has been abstracted and placed into these categories: technical, commercial, and health effects.

From a technical standpoint, it was possible to abstract a good deal of information from studies on large engines and their emissions. Though these are non-stationary sources with vastly different operating cycles, much of their technology coincides with the technology of small IC engines.

The most comprehensive study we found that dealt directly with emissions from small IC engines was made during 1973, by the Southwest Research Institute. Researchers there conducted a series of experiments on "Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines". Part Four of the series concentrated on small, air-cooled, spark ignition, utility engines. The exhaust products measured included total hydrocarbons, CO, CO_2, NO and O_2. An appendix to the report included raw emissions data based on several factors. To my knowledge, this data has not been subjected to a statistical analysis. Such analysis could assess the impact of the numerous control factors (i.e., mode, speed, power, temperature) on the level of emissions. This assessment could reduce the complexity of future statistical experiments. A part of the summary from the small IC engine section of the final report stated:

> "If it is decided that small engine emissions may become significant in the national picture, it seems obvious that further research would be required to establish a more reliable baseline. It would be necessary to first test additional engines of various sizes and types, preferably a statistical sampling of in-services units or long-term tests on new units. Other very weak points in the current status of information are number of engines in use, operating patterns, and annual usage."

The commercial abstracting consisted of reviewing small engine and engine driven equipment catalogs in addition to interviewing local dealers (who probably are not representative) and requesting information from various manufacturers of small engines. We had hoped that this information would allow estimations of numbers, distribution and usage patterns. Additional useful information could be directly derived from engine specifications. Such information would include:

- -cycle or stroke (two or four)
- -carburetor specifications
- -horsepower
- -tank design
- -tank size.

Tank size may seem insignificant as a variable at first glance; however, directly related to frequency of refueling are emissions by spillage and evaporation which may be significant.

Needless to say, much of this information is lacking both in terms of quantity and quality. A more precise estimate of numbers, distribution, and usage patterns could be obtained from a carefully designed sample survey.

There exists a literary void relating to the health effects of emissions from small IC engines. We may, or course, extrapolate our knowledge of known compounds and their impact on health to the quantity and distribution of these compounds attributable to small IC engines.

TASK 2: Analytical Equipment Sampling

The area of Analytical Equipment is one of rapidly developing technology. It is important to know what equipment is available with which characteristics and at what cost. Thus, this phase involved a compilation of the kinds of equipment available for sampling and an analysis of the proposed compounds. For current purposes, I shall describe the elements of a taxonomy of desirable information characteristics.

Taxonomic Dimension	Elements
Sampling	Method
	Volume
	Maximum Temperature Input
	Collection Efficiency
Performance	Accuracy
	Reproducibility
	Linearity
	Noise
	Log Time
	Retention Time
	Fall Time
	Zero Drift
	Span Drift
Operation	Ambient Temperature Range
	Temperature Compensation
	Relative Humidity Range
	Procedure
	Unattended Period
	Maintenance
Requirements	Power
	Weight
	Dimensions
Features	Output
	Training for Operation
	Cost

Elements of this taxonomy were filled by reviewing technical literature and equipment catalogues. This kind of information will allow the selection of equipment with optimal cost-effectiveness.

TASK 3: Experimental System Design

The Experimental System Design phase of the project is currently under way. The operational nature of these small engines makes the task of specifying the design of an experimental system which simulates various operating conditions quite difficult. Quasi stack and chamber techniques are currently being investigated. Upon completion, this system will include fuel monitoring and a means of containment of the exhaust from small engines with a variable conditioned dilution rate for primary and secondary emission evaluation. The system should be able to simulate environmental conditions typical of those in which the various small engines are used.

TASK 4: Statistical Experimental Design

The objective of the Statistical Design is to maximize the information for emissions assessment while minimizing the number of individual experiments. To illustrate the importance of this task, let us consider the factors by which engine emissions may vary significantly. As stated earlier, these factors are: age of engine, carburetor setting, revolutions per minute and mode. The stated level of interest of these factors are as follows:

-age: 0 and 5 years

-carburetor setting: manufacture rated, fuel lean and fuel rich

-rmp: 2,600 and 3,600

-mode; 0%, 50%, and 100%

If a full factoral ANOVA model is used, then the number of test runs would be:

3 (carburetor) X 3 (modes) X 2 (rpm) X 2 (age)
X 3 (engines) = 108 test runs.

This number of runs would be unreasonable in view of the time necessary in setting up an engine for testing. To compound the problem, particulate phase polynuclear aromatic and vapor phase polynuclear aromatic are both desirable and expensive to measure. Several incomplete factoral designs are under consideration as possible alternatives. To some the final statistical design extent will, depend on the final configuration of the experimental design. The greatest issue then becomes the obvious tradeoff between cost and precision. Precision, in any statistical experiment, is a direct function of sample size. With an appropriate design, we could retain sufficient sample size, yet reduce the number of required runs by deleting cells that are less important or informative. In conjunction with or in lieu of deleting less, informative cells, we may choose to reduce the number of replicates in any given cell. There are several possible ways of making a cell elimination decision. One would require analysis of existing data that would result in elimination based on least significant factors in a statistical sense. A more straightforward solution would involve making a judgment on defining the most "typical" cells corresponding to observed operational practices. Then emphasis could be placed on making runs which would produce maximum information in cells that best approximate the level of factors generally encountered during normal operations.

It is hoped that completion of this structured approach will provide a cost effective mechanism for the assessment of emissions of these important sources.

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San Francisco, California
March 5 - March 8, 1979

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